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US Army Corps
of Engineers

ENVIRONMENTAL IMPACT
RESEARCH PROGRAM

MISCELLANEOUS PAPER EL-89-4

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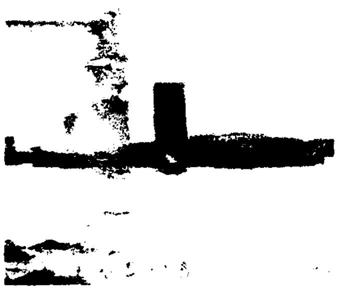
A WORKSHOP TO INVESTIGATE TECHNIQUES TO ANALYZE PHYSICAL AND BIOLOGICAL EFFECTS OF COMMERCIAL NAVIGATION TRAFFIC



by

Andrew C. Miller, Barry S. Payne

Environmental Laboratory

DEPARTMENT OF THE ARMY
Waterways Experiment Station, Corps of Engineers
PO Box 631, Vicksburg, Mississippi 39181-0631

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On 5-6 April, 1988, a workshop on commercial navigation traffic was held at the US Army Engineer Waterways Experiment Station (WES). The purpose was to review and discuss procedures for measuring physical and biological effects of commercial traffic in navigable waterways. The meeting was attended by personnel from WES, US Army Engineer District and Division Offices, Headquarters of the US Army Corps of Engineers, and the Board of Engineers for Rivers and Harbors.

Passage of commercial vessels through a waterway can cause water drawdown, waves, and brief periods of turbulence and elevated suspended solids. At the workshop it was determined that there is no evidence that commercial traffic negatively affects biota throughout navigable waterways. However, there is evidence that traffic can impact significant

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resources at specific sites. In addition, aquatic resources were altered by first-time dredging, channel realignment, and lock and dam construction.

Areas with significant resources likely to be affected by commercial vessels should be identified. Preliminary physical effects studies (changes in water velocity and direction) should be conducted to identify experimental and reference sites. A study should be designed to collect data on one or more of the following parameters: characteristics of individual species (physical condition indices), characteristics of dominant populations (evidence of recent recruitment and density), or community characteristics (species richness and diversity). Data from well-replicated studies can be used to evaluate existing conditions and to predict the environmental effects of incremental increases in traffic.

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PREFACE

In October, 1985, the US Army Engineer Waterways Experiment Station (WES) initiated a multiyear study on the environmental effects of navigation traffic in large waterways as a part of the Environmental Impact Research Program (EIRP). In April, 1988, a workshop was held at WES to investigate techniques to measure physical and biological effects of commercial navigation traffic. Participating in the workshop were planners, engineers, and biologists from Offices of US Army Engineer (USAE) Districts, Pittsburgh, Louisville, Nashville, Huntington, Mobile, St. Louis, and Rock Island, Offices of USAE Divisions, Ohio River and Lower Mississippi River Valley, Headquarters, US Army Corps of Engineers, and the Board of Engineers for Rivers and Harbors. This report includes papers presented by attendees and a summary of the major findings of the workshop.

Mr. Edwin A. Theriot was Chief, Aquatic Habitat Group; Dr. Conrad J. Kirby was Chief, Environmental Resources Division; Dr. John Harrison was Chief, EL; and Dr. Roger Saucier was Program Manager of the EIRP during the conduct of this project. The report was edited by Mrs. Gilda Miller, Information Products Division, Information Technology Laboratory.

COL Dwayne G. Lee, EN, is Commander and Director of WES. Dr. Robert W. Whalin is Technical Director.

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CONTENTS

CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
degrees (angle)	0.01745329	radians
Fahrenheit degrees	5/9	Celsius degrees or kelvins*
feet	0.3048	metres
g's, standard free fall	9.806650	metres per second squared
inches	25.4	millimetres
miles (US statute)	1.609347	kilometres
tons (2,000 pounds, mass)	907.1847	kilograms

* To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the following formula: $C = (5/9)(F - 32)$. To obtain kelvin (K) readings, use: $K = (5/9)(F - 32) + 273.15$.

Navigation Effects Workshop
US Army Engineer Waterways Experiment Station
Vicksburg, Mississippi
5-6 April 1988

ATTENDEES

US ARMY CORPS OF ENGINEERS

OFFICE, CHIEF OF ENGINEERS

John Anderson (CECW-RE)
Phil Pierce (CECW-PP)

BOARD OF ENGINEERS FOR RIVERS AND HARBORS

John Bellinger (CEBRH-EN)

LOWER MISSISSIPPI VALLEY DIVISION (LMVD)

W. E. Arnold (LMV)
John Brady (LMS)
Eugene Buglewicz (LMV)
Steve Cobb (LMV)
D. R. Gates (LMS)
Tom Holland (LMV)
Dave Leake (LMS)

NORTH CENTRAL DIVISION

Mike Cockerell (NCR)
Bob Vanderjack (NCR)

OHIO RIVER DIVISION (ORD)

Joe Cathey (ORN)
John Furry (ORH)
Fraser Gensler (ORP)
Don Hersheld (ORH)
Neal Jenkins (ORL)
Jack E. Kepler (ORD)
Jim Purdy (ORP)
Terry Siemsen (ORL)
Richard Tippit (ORN)
John Wright (ORP)

SOUTH ATLANTIC DIVISION

Glen Coffee (SAM)

WATERWAYS EXPERIMENT STATION (WES)

Rex Bingham (EL)
Mitch Granat (HL)
Carl Huval (HL)
Richard Kasul (EL)
Jack Kilgore (EL)
S. T. Maynard (HL)
Andrew C. Miller (EL)
Jean O'Neil (EL)
Barry Payne (EL)
Ed Theriot (EL)
J. S. Wakeley (EL)

Workshop to Investigate Techniques to Analyze Physical and Biological Effects of Commercial Navigation Traffic

AGENDA

5 April 1988

0800-0815	Welcome - Mr. Phil Pierce, Office of the Chief of Engineers
0815-0830	Purpose of Workshop - Andrew C. Miller, WES
0830-0900	Working Session I - Analysis of the Environmental Effects of Commercial Navigation Traffic and Habitats Likely To Be Affected
0900-0930	An Overview of Navigation-Related Studies - Selected Districts
0930-0945	Use of Aquatic Macrohabitats To Evaluate Water Resource Developments - Mr. Steve Cobb, LMV
0945-1000	Break
1000-1030	An Anthology of Locks and Dam 26 (Replacement) Project, 2nd Lock - Mr. Gene Buglewicz, LMV
1030-1100	A Conflict Resolution Method for Shoreline Management Decisions- Mr. David Gates, LMS
1100-1130	Techniques Under Development To Predict Navigation Traffic Impacts - Mr. Terry Siemsen, ORL
1130-1200	Development of Methods to Measure and Analyze Tow-Induced Physical Effects Related to Navigation Changes at Marmet Locks, Kanawha River, West Virginia - Mr. John Furry, ORH
1200-1300	Lunch (on your own)
1300-1315	Unique Aspects of Studies on Commercial Navigation Traffic Effects - Andrew C. Miller, WES
1315-1330	Techniques for Measuring the Physical Effects of Commercial Navigation Traffic - Andrew C. Miller, WES
1330-1400	Techniques for Measuring the Biological Effects of Commercial Navigation Traffic - Barry S. Payne, WES
1400-1430	Discussion
1430-1445	Break
1445-1530	Working Session II - Analysis of the Environmental Effects of Commercial Navigation Traffic and Habitats Likely To Be Affected
1530-1700	Techniques to Analyze Navigation Traffic Effects - Demonstrations
1700	Adjourn

6 April 1988

0800-0830	Summary of Day 1
0830-0945	Working Session III - Techniques That Can Be Used To Measure and Predict Biological and Physical Effects of Commercial Traffic

0945-1000	Break
1000-1130	Working Session III - Continued
1130-1300	Lunch (on your own)
1300-1400	Summary of Workshop, Concluding Remarks
1400	Adjourn

PURPOSE OF WORKSHOP

Andrew C. Miller*

Diverse opinions exist within the US Army Corps of Engineers on the nature of the environmental effects of commercial navigation traffic, with no consensus on the best way to measure and predict effects of increased traffic. As a result, the US Army Engineer Waterways Experiment Station (WES) and the Office, Chief of Engineers brought together key Corps personnel to discuss these issues. This workshop was attended by biologists and planners from the US Army Engineer District and Division offices who must evaluate environmental problems on major inland waterways.

This workshop was designed to consider techniques that could be used to:

1) Measure physical and biological effects.

2) Predict physical and biological effects of incremental increases in traffic.

This being a complex topic, it was decided that Corps of Engineers personnel should attempt to reach agreement on these issues before meeting with personnel in state and other Federal agencies.

Studies are being conducted at WES to determine the best procedures to measure biological effects of traffic. Such studies will provide quantitative data on the impacts on important biotic resources and will assist Corps personnel and other agencies concerned with commercial navigation traffic. Considerable time and funds may be saved if resource and construction agencies conduct well-designed studies that deal superficially with cause and effect and yield quantitative data. Environmental planners and biologists can then concentrate on other important issues. The credibility of state and Federal agencies will improve and, most important, the protection of significant resources along waterways will be increased.

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* Environmental Laboratory, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

ENVIRONMENTAL EFFECTS OF COMMERCIAL NAVIGATION TRAFFIC--WORKING SESSION I

Andrew C. Miller*

At the beginning of the workshop a questionnaire was distributed to all attendees. Participants were asked to respond to questions on the environmental effects of commercial navigation traffic before any discussion of these issues had taken place. A synthesis of the responses on the questionnaire are included as Attachment I. The first value in the response column is the median value, followed by the range of responses by the group. For example, in the "effects of unauthorized fleeting" the median of the group response was 3, with the range of responses from 1 to 5. It is apparent that the Corps staff had a wide range of perceptions concerning the negative effects of commercial navigation.

Attachment II includes the same questionnaire with responses supplied by the WES staff. These responses are based upon quantitative field data collected from a series of sites along navigable waterways, laboratory experiments on fish larvae, juvenile and adult mussels, and a review of much of the pertinent literature on commercial navigation traffic. Responses by WES staff members reflect little or no concern over large (and virtually unmeasurable) system-wide effects. However, negative physical and biological effects at sites with significant resources are often of concern and studies can be designed to resolve these questions.

Attachment III includes a questionnaire related to techniques for measuring environmental effects of commercial navigation traffic. The responses of attendees were not recorded. Responses by WES staff members are included.

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* Environmental Laboratory, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

ATTACHMENT I

Environmental Effects of Commercial Navigation Traffic
(Synthesis of Attendee Responses)

1 - Of no concern
2 - Of little concern
3 - Of moderate concern
4 - Of considerable concern
5 - Of great concern

I. Effects of navigation-related activities

3, 1-5	Unauthorized fleeting
4, 1-5	Construction dredging
2, 1-5	Lockages
3, 2-5	Stabilizing banks with riprap
3, 1-4	Placement of wingdams
2, 1-5	Leaving the sailing line during periods of high water

II. Effects of incremental increases of commercial traffic

Activity	Navigation Traffic	Barge Fleeting
Disruption of nesting raptors	2, 1-3	3, 1-5
Disruption of wading shorebirds	2, 1-3	2, 1-5
Bank erosion	3, 2-5	3, 1-5
Riparian habitat value	3, 1-5	3, 1-5

III. Effects of incremental increases of commercial traffic on aquatic habitat

	Traffic			Barge
	MC*	MCB**	Backwater	Fleeting
Increased resuspension and transport of particulates	3, 1-5	3, 2-5	2, 1-5	2, 1-5
Aquatic macrophytes	1, 1-4	3, 1-5	1, 1-4	2, 1-5
Abundance of adult mussels	3, 1-5	4, 1-5	2, 1-5	3, 1-5
Mortality of fish eggs and larvae	4, 1-5	4, 1-5	2, 1-5	3, 1-5
Abundance of adult fishes	3, 1-5	3, 1-5	2, 1-5	3, 1-5
Disruption of resting waterfowl	2, 1-3	3, 1-5	2, 1-5	2, 1-5

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* Main channel.
** Main channel border.

ATTACHMENT II

Environmental Effects of Commercial Navigation Traffic
(Synthesis of WES Attendee Responses)

1 - Of no concern
2 - Of little concern
3 - Of moderate concern
4 - Of considerable concern
5 - Of great concern

I. Effects of navigation-related activities

5	Unauthorized fleeting
5	Construction dredging
1	Lockages
2	Stabilizing banks with riprap
3	Placement of wingdams
4	Leaving the sailing line during periods of high water

II. Effects of incremental increases of commercial traffic

Activity	Navigation Traffic	Barge Fleeting
Disruption of nesting raptors	1	3
Disruption of wading shorebirds	1	2
Bank erosion	1	3
Riparian habitat value	1	5

III. Effects of incremental increases of commercial traffic on aquatic habitat

	Traffic			Barge
	MC*	MCB**	Backwater	Fleeting
Increased resuspension and transport of particulates	1	2	1	3
Aquatic macrophytes	1	1	1	3
Abundance of adult mussels	1	1	1	3
Mortality of fish eggs and larvae	1	1	1	2
Abundance of adult fishes	1	1	1	2
Disruption of resting waterfowl	1	1	1	3

* Main channel.
** Main channel border.

ATTACHMENT III

Techniques to Measure Environmental Effects
of Commercial Navigation Traffic
(WES Responses)

1. Effects of water drawdown on nearshore habitats 4,6

2. Development of a barge fleeting area adjacent to a mussel bed 5

3. Development of a barge fleeting area near a valuable riparian habitat 2,4,6

4. An increase in pool levels by 10 ft* as a result of lock and dam construction 1,2

5. An increase in pool levels by 1 to 2 ft as a result of lock and dam construction 2,4

6. Sediment resuspension in a backwater habitat 4,6

7. Physical disruption of benthic substrates at a barge turning basin 5,6

8. Effects of wave wash on near-shore and riparian habitat 4

9. Effects of sedimentation on aquatic macrophytes 4,5

10. Effects of barge fleeting on nesting eagles 4,5

11. Effects of commercial traffic on resting waterfowl 4

12. Effects of turbulence on fish populations 5

13. Analysis of the nutrient budget of a backwater lake 3

14. Dredging and dam construction on a second order stream 1,6

Choose one or more of the following for 1-14 above:

1. Aquatic habitat evaluation method
2. Terrestrial habitat evaluation method
3. Energy flow model
4. Observations to determine if there is an effect
5. Annual measures of density, population structure
6. Specific study to first determine if important resources are present

* A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page 3.

THE VALUE OF SCIENTIFIC LITERATURE IN THE STUDY OF NAVIGATION TRAFFIC EFFECTS

Andrew C. Miller*

Scientists conducting field or laboratory studies for Federal agencies can communicate their results through two types of written media: government (or contractor) reports, and the refereed literature. The former consists of technical reports or miscellaneous papers that are funded by the sponsoring agency. A specific study could result in the publication of 50 to more than several hundred copies of a report, most of which go to the sponsor. If a project is controversial, the report may be requested by a local conservation agency or other interested individuals. Conversely, the refereed literature consists of scientific journals with a national or international distribution (Ecology, Limnology and Oceanography, or American Midland Naturalist), and local publications with more limited distribution (Mississippi Academy of Sciences, Kentucky Academy of Sciences, etc.). To the nonscientist it might appear that these two types of publications are quite similar, although they are not. The key difference in them lies in the review they receive prior to publication. Material for a refereed journal will be published only after it receives a favorable review by two or more individuals with a demonstrated knowledge of the subject matter. Many journals accept 50 percent (often much less) of the material they receive. A thorough review takes into consideration all aspects of the work: methods and materials used, nature of the results, discussion of findings, and interpretation of previously completed research. Most reports of contracted studies do not receive such technical review. This does not suggest that government (nonrefereed) reports are filled with erroneous material. However, most government publications have not been subjected to a rigorous scientific peer review before publication.

Many nonrefereed reports on commercial navigation traffic are extremely speculative in nature. An example from a government report follows: "Noises due to tow traffic may decrease [bird] nesting productivity and increase stress." The lack of supporting evidence for this statement makes it

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* Environmental Laboratory, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

impossible to determine its validity. It is very unlikely that such statements would appear in the refereed literature.

Frequently an author will reference a "personal communication." This information is unpublished and, therefore, has not been critically examined. A personal communication should not be used to build a case for important conclusions but for minor observations or techniques that the original author did not desire to publish. Much of the nonrefereed literature on effects of commercial navigation traffic contains far too many unsubstantiated personal communications.

Occasional scientists are criticized for what appears to be an overemphasis on writing and submitting results to refereed journals. However, there are many valid reasons for preparing results of certain studies for a technical journal. Most important, the manuscript receives a critical review from experts in the field less likely to have preconceived notions of expected results. Even if the material is not accepted, the author usually receives a thought-provoking and constructive set of comments. When a paper is published by a scientific journal it immediately becomes easily assessable to the widest possible audience. Well-known journals are received by major libraries and university throughout the world. It is not uncommon to receive hundreds of requests for copies of papers published in a fairly small journal. The credibility of a scientist is enhanced if he publishes in scientific journals, thereby gaining for him a reputation for successfully completing certain types of studies.

Obviously scientists in government agencies can not expect to publish all of their findings in the refereed literature. Many times a study is conducted that has a local and specific purpose. For example, a government-sponsored study might be designed to determine whether or not rare or endangered species inhabit an area. Such negative data may be useful for planners, but is unlikely to be accepted by a national journal. Often it is possible for scientists in government to publish selected results of technical reports in the refereed literature. The sponsors of studies that result in dual publication should be aware that the quality of their written product, and ultimately of additional studies through the same workers, will be improved if there is an effort to publish in technical journals.

EFFECTS OF COMMERCIAL TRAFFIC ON MUSSEL RECRUITMENT IN THE EAST CHANNEL OF THE MISSISSIPPI RIVER NEAR PRAIRIE DU CHIEN, WISCONSIN

Andrew C. Miller*

Background

Movement of commercial navigation vessels can cause periods of turbulence, wave wash, and elevated suspended solids. Biologists and planners in the Corps of Engineers and in resource and conservation agencies are concerned that incremental increases in commercial navigation traffic could negatively affect valuable and sensitive aquatic resources. Currently, the Corps is attempting to analyze the environmental effects of increased commercial navigation traffic, which can result from planned waterway modifications on major river systems throughout the United States.

A "system-wide" analysis should consist of a set of detailed studies at a few representative sites. Results of these site-specific studies will then be applicable throughout the waterway. A "system-wide" Environmental Impact Statement should contain a series of site-specific studies applied to a large river reach.

Effects of Navigation Traffic At An Upper Mississippi River Site

In conjunction with personnel of the US Army Engineer District, St. Paul, WES is conducting a navigation effects study in the East Channel of the Mississippi River near Prairie du Chien, WI (River Mile 635). At this location there is dense and diverse mussel bed which supports commercially valuable (*Amblema plicata*) and endangered species (*Lampsilis higginsi*). Studies are being conducted at two sites, a turning basin used by barges approaching a loading facility, and at a reference site located 1 km downriver. In 1986 there were a total of 518 commercial tow events (passage of a vessel) in the East Channel.

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* Environmental Laboratory, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

The barge turning basin was last dredged in 1976 to provide access to the loading facility, although no dredging occurred at the reference site.

Methods

Divers collected 30 quantitative samples (0.25 m^2) for mussels at each of the two sites (a total of 60 samples was obtained). Each site consisted of three subsites with ten samples collected at each subsite. Samples were sieved and all live organisms were removed. All mussels were identified, weighed, and measured.

Objective

The objective of this work is to determine if movement of barges in the turning basin affects recruitment of freshwater mussels. A population that is "recruiting" successfully produces viable juveniles. Evidence of recent recruitment (presence of juveniles) was used as an index of the health of the mussel bed and as a measure of physical conditions of habitat.

Results and Discussion

The density of juvenile and large-sized *Amblema plicata* at the two sites is depicted in Figure 1. For this work juvenile mussels were defined as being less than or equal to 35 mm total shell length. The density of large mussels (i.e., individuals greater than 35 mm) was significantly less ($p < 0.01$, Duncan's multiple range test) at the barge turning basin (Site I) than at the reference site. The dredging that took place in 1976 removed a substantial number of large mussels. However, the number of juvenile mussels was not significantly different between sites. This demonstrates that mussels were able to successfully reproduce and colonize a previously dredged area and that recruitment was unaffected by commercial navigation traffic.

Summary

The study at Prairie du Chien has provided information on the environmental effects of commercial navigation traffic. A determination of recent

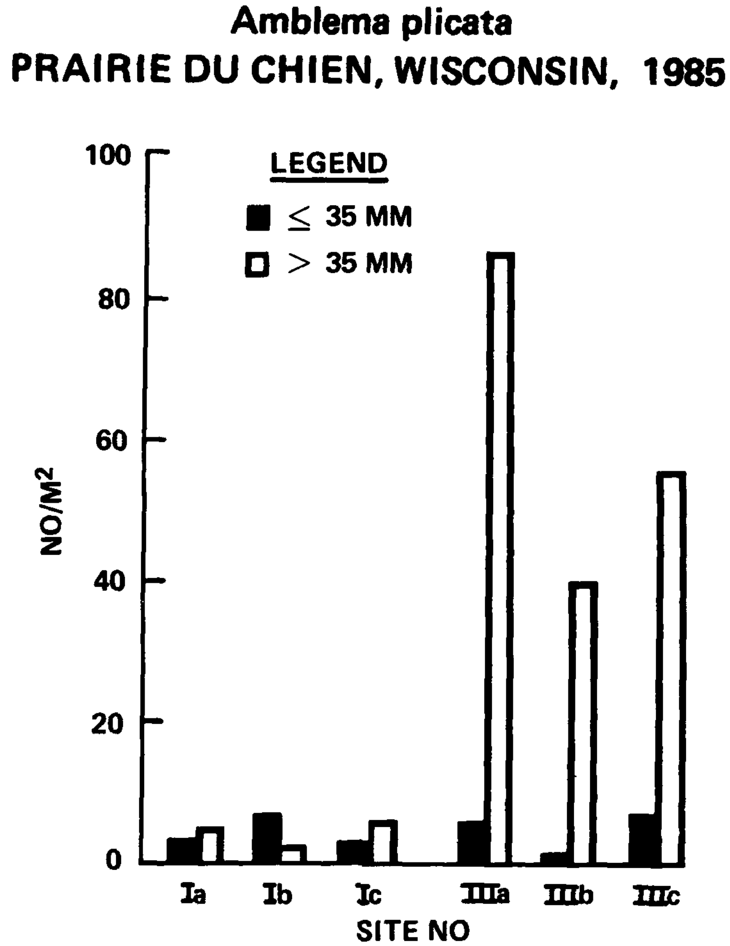

Figure 1. Differences in density of adult and juvenile Amblema plicata at barge turning basin dredged in 1976 (Site I, which consisted of three subsites, a, b, and c), and a reference site (Site III, which also consisted of three subsites) located downriver

mussel recruitment provides a useful indicator of past and present conditions of habitat. Commercial navigation traffic, at least at these levels, has not had a detrimental effect on mussel recruitment at a barge turning basin at Prairie du Chien. This study dealt specifically with freshwater mussels, however, similar studies could be conducted with other valuable biotic resources.

Results from a few important sites can be applied to similar sites throughout a navigable waterway. An analysis of "system-wide" effects should be based on information gained at representative sites.

NASHVILLE DISTRICT OVERVIEW OF NAVIGATION RELATED STUDIES

Richard Tippit*

Major River Basins

The US Engineer District, Nashville, consists of two major river basins; the Cumberland River and Tennessee River. Since the early 1800's both have been altered to support commercial navigation.

Tennessee River

The Tennessee River is navigable throughout its entire 652-mile length, from the confluence with the Ohio River upstream to Knoxville, Tenn. A system of seven main-stem dams and ten locks currently exist on the Tennessee River. The Tennessee River is part of a complex system of waterways supporting commercial navigation. It is linked to the Gulf of Mexico via the Tennessee-Tombigbee Waterway, and is connected to the nearby Cumberland River through a canal between Kentucky Lake and Lake Barkley. The Tennessee River is connected to the Mississippi River navigation system via the Ohio River.

Cumberland River

The smaller Cumberland River (Figure 1) has been developed for navigation with a system of four main-stem locks and dams. A navigation channel is

Figure 1. A commercial tow navigating a bend on the Cumberland River, mile 3

* US Army Engineer District, Nashville, Nashville, Tenn.

maintained from the confluence with the Ohio River to mile 385.0. Like the nearby Tennessee River, the Cumberland River is linked with other inland waterway systems supporting navigation traffic. The city of Nashville, Tenn. is the main destination for navigation traffic on the Cumberland River.

Modified Aquatic System

Virtually all of the main-stem locks and dams on the two rivers were completed and operational before passage of many laws and regulations which would have required assessment of impacts of their construction and operation. The result is a highly modified aquatic system in both the Tennessee River and Cumberland River.

Presently the focus of navigation related studies and concerns in the Nashville District is concentrated at the lower reaches of both rivers. Kentucky Lock, located on the Tennessee River at mile 22.5, forms a bottleneck for navigation traffic. The lock at Kentucky Dam is old and relatively small, 110 ft wide by 600 ft long, and has for the past few years operated at or near its lockage capacity. Nearby Barkley Lock at mile 30.5 on the Cumberland River is underutilized by navigation traffic, even though there is access for traffic between the Cumberland and Tennessee rivers via a short canal upstream of Kentucky and Barkley dams. Most commercial traffic entering the system uses Kentucky Lock due to the wide and easily navigable nature of the Tennessee River below Kentucky Dam. In contrast, the channel of the Cumberland River below Barkley Lock and Dam is much narrower and generally twisting, with several bends that may pose major difficulties for tows attempting transit. Rapid fluctuations in water levels resulting from hydropower operations further hinder navigation. During the summer of 1986 when Kentucky Lock was closed for maintenance, all traffic used the Cumberland River below Barkley Dam. The difficulties faced by large tows attempting to transit the reach of river below Barkley Lock was evident. Tows up to 1,200 ft in length had to maneuver through several constricted bendways on the 30-mile reach of the lower Cumberland.

Kentucky Lock Traffic Congestion

Several plans have been set forth to relieve the traffic congestion at

Kentucky Lock (Figure 2). Potential solutions range from construction of a new and more efficient lock at Kentucky Dam to modifying the Cumberland River below Barkley Lock, making it more conducive to carrying navigation traffic. The latter plan would involve the widening of the river at critical narrow points which would ease passage of tows. Regardless of which solution or combination of plans is adopted, the result will be more traffic using the Tennessee and Cumberland rivers. Consequently, a need exists to assess what impacts, if any, traffic increases could have upon the waterways.

Figure 2. Kentucky Lock and Dam, located near Paducah, Ky.

Impact Assessment of Traffic Increases

Before impacts of traffic increases can be assessed, the aquatic system in place must be thoroughly defined. Its stability must first be established. It must be determined whether or not the aquatic system present is profoundly

different from the original, natural condition that once existed in the river. Habitats must be defined and the likelihood of impact from traffic assessed. Impacts to the aquatic environment must be separated based on those resulting from normal operational or natural events and those impacts caused by commercial traffic.

Possible ways of assessing impacts could be investigation of plankton or benthic invertebrates exclusive of mussels. Neither of these communities, however, would seem particularly suitable due to their ephemeral nature, seasonal cycles of abundance, and difficulty of sampling. Another avenue of investigation is to examine those aquatic resources which are ecologically or economically significant within the system. Since fisheries are a significant resource, one investigation undertaken within the Nashville District has been the use of hydroacoustics to define the seasonal distribution of fish within the Cumberland River below Barkley Lock. Hydroacoustics was also used to investigate fish behavior during tow passage events. Results from these studies were enlightening, and the technique holds promise as a useful tool for defining fish behavior in response to environmental perturbations, including tow traffic.

In summary, data are needed that can be used to communicate with agencies charged with fish and wildlife concerns. If a firm ecological base of information relative to impacts of tow traffic increases is established, then a solid foundation will exist for defining possible mitigation or dismissing supposed concerns about environmental consequences of increased navigation traffic.

Other studies being pursued within the Nashville District relative to navigation concerns include the possible modification or upgrade of locks throughout much of the upper Tennessee River system. In addition, the Operation and Maintenance Environmental Impact statements for both the Tennessee River and Cumberland River are obsolescent and in need of being replaced with updated, scientifically valid documents.

A CONFLICT RESOLUTION METHOD FOR SHORELINE MANAGEMENT DECISIONS

David R. Gates
and
Kenneth R. Porter*

Abstract

A conflict resolution procedure is described for the management of future development activities along shorelines. The Corps of Engineers' study of barge fleeting at Alton Lake, Illinois and Missouri is cited as an example of the procedures application. Fleeting at this lake had become a contentious resource use with both navigation and environmental interests strongly polarized. The study process included the development of resource inventory and sensitivity maps, resource profiles, alternative plans, and a trade-off analysis. Map development was an interagency work team effort supplemented by public workshop participation. Using this information, the Corps of Engineers developed three comprehensive management plans: (1) a Minimum Constraints Plan representing the polar interests of navigation, (2) a Maximum Constraints Plan representing the polar interests of environmentalists, and (3) an Intermediate Constraints Selected Plan developed through trade-off analysis. By avoiding high-sensitivity areas and by applying special permit conditions, cumulative impacts were held low while at the same time the resource interests of all lake users were accommodated.

Background

Alton Lake (i.e., Navigation Pool 26) is located on the Mississippi and Illinois Rivers 30 km north of St. Louis, Mo. The study area included 60 km of the Mississippi River, and the lower 10 km of the Illinois River. The area has many significant resources: aesthetic (a national scenic highway), biological (a national wildlife refuge, state wildlife management areas, private waterfowl hunt clubs, commercial and sport fishing areas, mussel beds, Federal and state endangered species habitat), cultural (national historic register

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districts), recreational (harbors, marinas, boating areas, beaches), and navigational (a national waterway for commercial traffic, and a strategic support area for industrial and commercial water-dependent developments). There are 280 km of shoreline within the study area, including side channels, backwaters, and the main stem. A total of 15 km of shoreline is currently used for fleeting, and an additional 30 km is physically suitable for fleeting in the future.

Fleeting areas are sites located outside of the navigation channel where barges are regrouped for further transit. Functionally, fleeting areas are to the navigation industry what switchyards are to the railroad industry. The processing and issuance of permits for fleeting in Alton Lake had become problematical in recent years. Permit requests, at one time routinely granted, had become highly contentious with navigation and other interest groups strongly divided. Issues raised by opponents of fleeting were: the obstruction of scenic vistas; impacts to sportsmen, bald eagles, mussel beds, and commercial fishing; concern for historic sites; hazards to recreational boaters; the need for alternative fleeting sites; and the need for a comprehensive master plan and environmental impact statement (which should include a discussion of lake-wide cumulative impacts). Proponent arguments for fleeting included energy savings, efficient use of the water surface, expected benefits to the local economy and employment, and the strategic need for fleeting in the requested location.

In an initial public meeting, the Corps proposed a comprehensive study approach as an attempt to resolve the conflict. Limited funds and time (1 year) were major study constraints. The study was to be documented as an update to the Pool 26 Master Plan for navigational operations and maintenance (US Army Engineer District, St. Louis 1985a). This revision was also to be accompanied by an Environmental Impact Statement (US Army Engineer District, St. Louis 1985b).

Study Procedure

The study was accomplished in eight steps: (1) development of resource inventory maps, (2) development of resource sensitivity maps, (3) identification of potential fleeting sites, (4) development of resource profiles, (5) development of preliminary plans, (6) preliminary plans evaluation,

(7) development of the selected plan, and (8) selected plan evaluation.

Step 1. Resource Inventory Maps

The first phase of the investigation was a combined and cooperative work effort by concerned Federal and state resource agencies. To facilitate the collection and analysis of resource information, seven interagency resource teams were formed. These were the aesthetic, biological, cultural, recreational, water quality, navigational, and institutional teams. Among the participating agencies were the US Coast Guard, Illinois and Missouri Departments of Transportation, US Fish and Wildlife Service, Illinois and Missouri Departments of Conservation, Missouri Department of Natural Resources, and the US Environmental Protection Agency. The input from the teams was the single most important element of the study.

Each team consisted of a group of resource experts, each representing an agency responsible for a particular resource, and a group facilitator from the Corps of Engineers staff. In addition to being active team members, the facilitators were responsible for the scheduling and initiation of team meetings, and for the coordination of input into the overall study effort.

Resource inventory maps (Figure 1), in addition to written documentation, were developed by each team for the entire shoreline of the lake. This work was based primarily on existing data. A major exception to this was the aesthetics inventory for which no previous information was available. In an

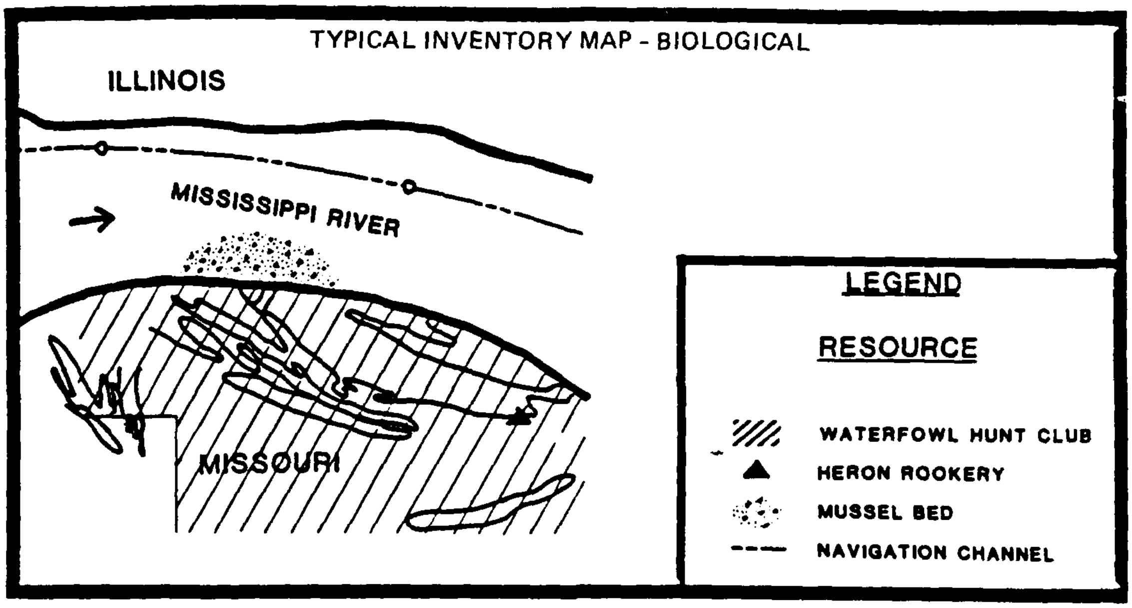

Figure 1.

informal workshop, the public was given an opportunity to provide additional data, to ask questions, and to make comments on the draft inventory maps.

Using a modified version of the US Bureau of Land Management's (BLM) Visual Resource Management Methodology (US Department of the Interior 1984), the aesthetics team conducted an extensive and intensive inventory of the scenic attributes of Alton Lake. Two inventory maps were developed, a scenic quality map and a public concern map. The lake was divided into evaluation subunits based on similarities of landform features, vegetation types, and land use. The overall scenic quality of each subunit was determined by evaluating seven key factors: landform, vegetation, water, color, influence of adjacent scenery, scarcity, and cultural modifications. A point system was used to assign importance values to each factor. Based on total point values, each subunit was given an overall rating of high, moderate, or low scenic quality. These ratings were then mapped for the lake. Photographic panoramas and detailed worksheets were developed for each sample site. To determine public concern for aesthetics, each subunit was then evaluated for the key factors: type of user, amount of use, public interest, adjacent land uses, and special areas. Public meeting records and workshops, news articles, and general land-use information served as the primary sources of data.

The biological inventory maps reflected the prior mapping efforts of the US Fish and Wildlife Service (USFWS). The USFWS had previously coordinated its mapping through numerous meetings with state conservation agencies and resource users. Five different inventory maps were prepared to depict the biological resources: fisheries habitat, wildlife habitat, fisheries use, wildlife use, and rare and endangered species.

The cultural team conducted a search of the state cultural resource inventory files, as well as the current listing of the National Register of Historic Places. Data sources utilized by the recreation team included: a 1977 Master Plan for Alton Lake, the Great River Resource Management Study, the Corps' recreational permits and lease files, public meeting input, a Labor Day weekend helicopter survey of recreation use in the lake, and an onsite inspection by boat. The inventory map featured boat harbors, boat clubs, marinas, parks, cabins, beach recreation, camping, and high-use boating areas. The water-quality team mapped the locations of hazardous pipelines, water intake structures, and potential contaminant-containing sediments. The inventory map prepared by the navigational team included project operations (i.e.,

locks and dams, dredge sites and disposal areas, and navigation channel), existing fleets, docks, and terminals. The institutional resources were not inventoried using a team concept per se; rather, the Corps gathered the relevant data from written sources and coordinated with appropriate governmental entities. Two institutional resource maps were developed: (1) land ownerships and zoning, and (2) land uses.

Step 2. Resource Sensitivity Maps

Sensitivity maps (Figure 2) were developed by using the inventory maps,

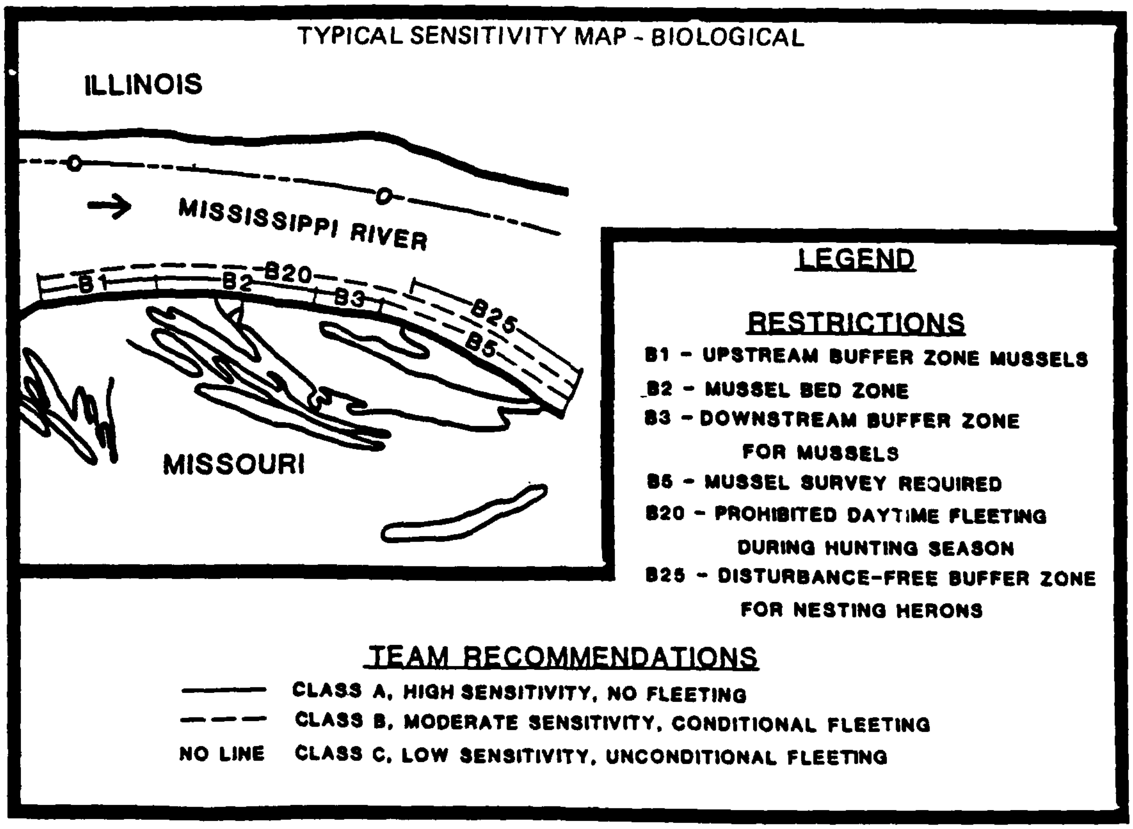

Figure 2.

and team perceptions of how the resource base could be affected by the impacts of fleeting. The determination of impacts was based on existing methods, and on the collective professional judgement of each team. A three-class system for designating resource sensitivity was used by the teams with the classes defined as: Class A Areas - locations highly sensitive to fleeting with a recommendation that no fleeting be allowed; Class B Areas - locations moderately sensitive to fleeting with a recommendation for fleeting only with

special conditions; Class C Areas - locations for fleeting with no conditions. Class A and B shoreline areas were also given coded notations to indicate the specific nature of the team recommendations for safeguarding the resources. Sensitivity maps and restriction notations of each team reflected a resource-specific perspective, and gave no consideration to the accommodation of other resource needs where conflicts existed. A second workshop was held to offer the public an opportunity to review and comment on the sensitivity maps.

In determining the aesthetic impacts of future fleeting, the resource team utilized a contrast rating system, conceptually similar to that used by BLM. The basic philosophy was that the degree to which a developmental activity affects the visual quality of a landscape depends on the visual contrast created between the project features and the major features in the existing landscape. The basic design elements of form, line, color, and texture were used to make this comparison, and to describe the visual contrast created by the project. The final sensitivity designations for each unit of shoreline were arrived at by giving equal weight to rating factors of scenic quality, public concern, and contrast.

Very little information was available on the effects of fleeting on fish and wildlife. In lieu of such information, the biological decisions had to be based primarily on professional judgment. To obtain better information on potential impacts, a guild-style approach coupled with network diagrams was used. A guild is defined as a "group of species that exploit the same class of environmental resources in a similar way" (Severinghaus 1981). Theoretically, actions impacting one member of a guild should impact other members of that guild in a similar way. Guild species were selected to provide general representation for a wide spectrum of regionally applicable guilds for various habitats, and to provide representation for species of special public or agency interest. Network diagrams similar to that described by Sorenson (1971) were used to show sources of impact to the guilds. The most highly sensitive shoreline areas identified by the team were: adjacent to backwaters used by waterfowl, lands managed for waterfowl, commercial and sport fishing zones, mussel beds, eagle feeding and resting sites, and heron feeding and nesting sites.

In terms of cultural resources, the shorelines in the immediate vicinity of two historic districts were rated as highly sensitive. The team was concerned that adverse effects would stem from the alteration of the natural

setting of these areas. The undeveloped backdrop surrounding these sites was an integral part of its historical character. High-sensitivity factors for recreation included: access to commercial harbors and marinas, private properties subject to disturbance such as residences and cabins, constricted areas with little maneuvering space for boaters, and access to beaches. Areas indicated as sensitive by the water quality team were an ammonia pipeline crossing and an area of potentially contaminated fine clay sediments. For safety reasons, the navigational team indicated that project operations were highly sensitive to fleeting. No sensitivity mapping was required for the institutional portion of the study.

Step 3. Potential Fleeting Sites

Fleets require areas immediately adjacent to the shoreline with water depths greater than 10 ft. Hydrographic charts were used to determine the location of potential fleeting sites.

Step 4. Resource Profiles

Resource profiles were developed as a compilation of resource map sensitivities for the specific locations identified in step 3. Sample profiles are displayed in Figure 3.

Step 5. Preliminary Plans Development

Initially, two plans were developed. Each plan represented an opposing perspective on the management of fleeting in the lake. These plans were the Minimum Constraints Plan (MIN) and the Maximum Constraints Plan (MAX). The MIN plan recognized only the minimum environmental constraints mandated by Federal law (e.g., endangered species). This tended to deem as potentially fleetable any deep water location irrespective of its environmental sensitivity. The MAX plan was designed to discourage fleeting in locations identified by any resource team as highly sensitive. Due to the many competing uses on the lake, few sites were found to be acceptable for fleeting.

Step 6. Preliminary Plans Evaluation

In the light of past controversy, it became readily apparent that while the MIN Plan would be highly favorable to industry, it would not be regarded by the public and agencies as being representative of all resource demands. At the other extreme, the MAX plan was strong environmentally but provided little benefit from a navigational standpoint. The plan provided little space for future fleeting and few siting alternatives to meet the varied needs of fleeters. As with the MIN Plan, there was a gross imbalance of interests.

RESOURCE PROFILES

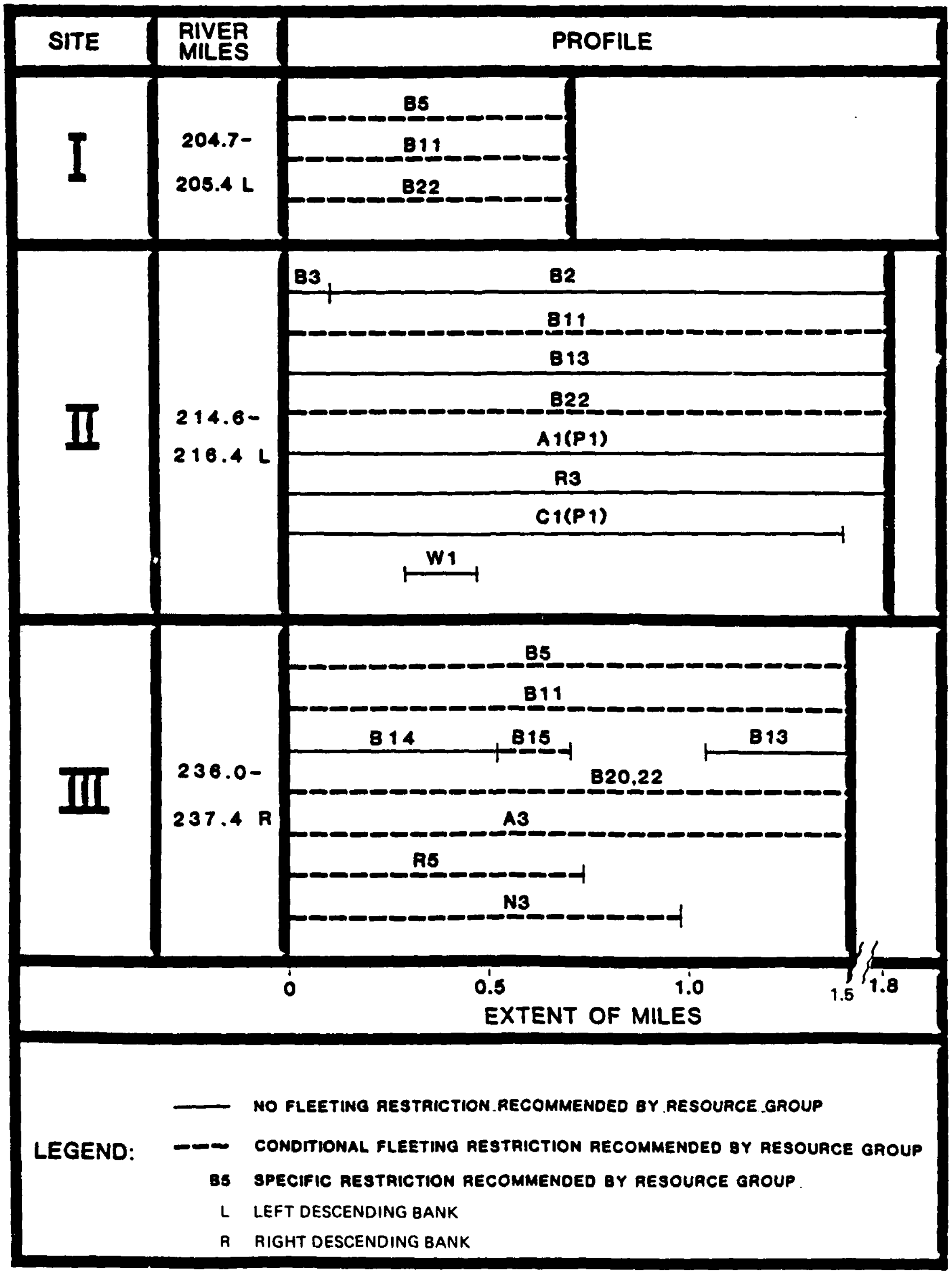

Figure 3.

Step 7. Selected Plan Development

In recognition of the fact that the Corps of Engineers has a Congressional mandate to serve as the steward of all resources of the lake, it was apparent that a trade-off analysis was required. As a first step in this analysis, intermediate level management constraints were developed by the Corps of Engineers. These decision variables were formulated using the team-generated resource profiles as a guideline, and in a manner cognizant of all resource interests (Table 1). Some of the recommended restrictions of the teams were adopted in their entirety, while others were modified due to other resource concerns. Next, based on the specific resource constraints at each potential fleeting site (Table 2), a professional judgement was made as to the acceptability of each site for fleeting. Note that in Table 2, "safety" as a site-related navigational resource problem was treated as a "fatal flaw." Regardless of how acceptable the site was from the perspective of the other resources, the site was designated as unacceptable. The described screening process, along with agency and public feedback, resulted in the Corps' selected management plan.

No specific mileage of fleetable shoreline was identified for the selected plan; however, it was decided that (1) the plan should reflect a reasonable allocation and distribution of space sufficient to meet any likely short-term fleeting needs, and (2) it should reflect minimal cumulative impacts if all designated areas were actually fleeted.

Step 8. Selected Plan Evaluation

Due to distributional problems, 2 of the 28 potential fleeting sites were redesignated from unacceptable to acceptable. By the deliberate exclusion of site locations with high overall resource sensitivity, and through the inclusion of special permit conditions, potentially overall adverse site-specific impacts were minimized. This strategy was also effective in reducing the potential cumulative impacts of the plan (Table 3). This was true even if, as a worst case, all of the designated sites were actually fleeted.

Conclusions

The procedure is consistent with the principles and guidelines established for the planning of Federal water resource studies (US Water Resources Council 1983). Unique aspects of the procedure are the graphic line display

of multiresource sensitivities, and the degree of agency and public participation in the determination of management decision variables.

With minor modification, this procedure could be applicable to many types of shoreline-based activities. The advantages of the technique are numerous: (1) provides a framework for incorporating public and agency input, (2) more time and cost efficient than overlay methods, (3) provides an audit trail for decisions, (4) provides a mechanism for identifying and reducing cumulative impacts, (5) emphasizes the use of special conditions as a means of reducing development impacts, (6) provides potential developers with a more comprehensive understanding of an area's environmental and navigational constraints, thus making site selection more efficient, (7) reduces the need for extensive environmental documentation of individual activities since reference can now be given to the more comprehensive generic documentation, (8) reduces permit delays via items 7 and 8 above, and (9) should reduce litigation via conflict reduction.

The trade-off analysis procedure could be modified to provide a more numerically derived determination of site acceptability for development. The resource constraints given letter designations in Table 2 could be converted to numerical values using scaling, rating, or ranking methods. In addition, the individual resources could be weighted using the ranked-pairwise comparison technique or a similar method. Canter, Atkinson, and Leistritz (1985) provide an excellent summary of weighting-scaling/rating/ranking methods for the assignment of numerical values.

In regard to fleeting, the US Department of Transportation (US Department of Transportation 1984) has developed a comprehensive checklist of criteria for evaluating site suitability. These criteria deal with site acceptability, mainly considering economics and operational needs. Some of the criteria could further enhance a region-wide type analysis for navigation constraints (Table 2). However, probably all of the criteria of the US Department of Transportation should be thoroughly considered by a fleeter prior to submitting a site-specific permit application.

No specific determination was made of a "saturation point" for barge fleeting at Alton Lake. Such a determination was not considered relevant to this particular study. It had taken 50 years to consume 15 km of the shoreline with fleeting. The selected plan provided for this much space again, and with minimal impacts only. However, at some point in the future it may become

more urgent to define resource saturation levels. Although input from the public and agencies might be a useful indicator of such saturation, it should not be the sole basis for this determination. This statement is made in view of the fact that the public, as represented by local public meetings, may not be totally representative of public interest at large. For example, public attendance for Alton Lake meetings was represented for the most part by recreational users. The nationwide public interest in the economic benefits of transporting grain, petroleum, chemicals, and other vital products was largely unrepresented.

For many "special interest" groups within the public, and for even certain agencies with more limited resource jurisdiction (e.g., water quality or fish and wildlife), there is no acceptable level of compromise or "trade-offs" possible. For agencies such as the Corps of Engineers with broad management responsibilities and legal mandates to provide for all resource users, the concept of trade-offs is not only viable, it is a necessity. The total resolution of all resource conflicts is probably infeasible and even unrealistic. However, use of the described procedure does help to minimize conflicts. The method achieves the protection of the most important and critical portions of each resource.

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Table 1

Example Rationale for Resourre Trade-off Analysis

CULTURAL RESOURCES

Shorelines

Corps Management Perspectives

The shorelines in the immediate vicinity of the Elsah and Chautauqua historical districts are highly sensitive to fleeting. Potentially adverse effects would stem from the alteration of the natural setting adjacent to these villages. This natural setting is an integral part of the historical character of these two communities. Impacts along the Great River Road (near bank) are perceived as being more critical to avoid than impacts eminating from the more distant Portage Island or Slim Island shorelines (far bank). Historic site impacts are best offset by area avoidance.

Previously undisturbed locations should include a special permit condition requiring the monitoring of excavations for the placement of mooring devices. This is to protect both known and as yet unknown archealogical features.

Corps Management Constraints

Major Constraints - Shoreline areas adjacent to the Great River Road near the historical districts.

Moderate Constraints - Shoreline areas along the northside of Portage and Slim Islands.

Minor Constraints - All remaining lake areas, provided that excavation monitoring is included as a permit condition.

BIOLOGICAL RESOURCES

Mussel Beds

Corps Management Perspectives

The precise impact relationships between fleeting and mussels are not yet fully understood. As a resource safeguard, total destruction will be assumed where mussel beds conflict with a given fleeting site.

This resource is best managed by avoidance. However, provided the cumulative impacts can be held to low or moderate levels, some direct impact to known mussel beds is considered acceptable. Mussels do not represent a finite resource; that is, similar mussel populations exist in other lakes of the Upper Mississippi River System. Since endangered species are not present - conservation of the resource, not preservation, will be the operative principle applied.

No special permit conditions are included for mussel beds. The District will not require applicants to fund studies to determine the absolute presence or absence of mussel beds. However, it will give consideration to any relevant site-specific data furnished by agencies during the normal permit evaluation process.

(Continued)

Table 1 (Continued)

Corps Management Constraints

Major Constraints - None.

Moderate Constraints - Areas directly over or immediately upstream or downstream of mussel beds.

Minor Constraints - All remaining lake areas.

Table 2

Trade-off Analysis Matrix (Example of site specific resource constraints and determination of site fleetability for selected plan)

			Resource						
Area#	Location	River Miles	Aesthetics	Biological	Cultural	Recreation	Water Quality	Navigation	Potential Fleetability
I	Alton	204.7-205.4 L	C	C*	C	C	C	C*	AC
II	Chautauga	214.6-216.4 L	A	C	A	A	C	C	UN
III	Gilbert Lake	4.4-5.1 L (IL.R)	C	B*	C*	C	C	C*	AC
IV	Iowa Island	223.6-224.4 R	C	C	C	B	C	F	UN

CODE:

A	Major constraints	F	Fatal flaw (safety)
B	Moderate constraints	AC	Acceptable
C	Minor constraints	UN	Unacceptable
L	Left descending bank	R	Right descending bank

* Special permit conditions are included as part of the site's indicated constraint.

Table 3

Example: Cumulative Effects Evaluation Matrix for Alternative Plans

Resource	High Sensitivity Resource Identified, km	Maximum Constraints Plan		Minimum Constraints Plan		Selected Plan	
		Conflict	Effects	Conflict	Effects	Conflict	Effects
Recreation	125	0 (0%)	C	21 (17%)	B	6 (5%)	C
Cultural	6	0 (0%)	C	5 (83%)	A	0 (0%)	C
Aesthetics	115	0 (0%)	C	20 (17%)	B	5 (3%)	C
Biological							
- Comm. Fisheries	75	0 (0%)	C	15 (20%)	B	5 (7%)	C
- Mussel Beds	15	0 (0%)	C	5 (33%)	B	2 (13%)	C

CODE: A Potential for major adverse effects
B Potential for moderate adverse effects
C Potential for minor or no adverse effects

* In the absence of a Comprehensive Management Plan, the effects of a No Action Plan would be similar to the MIN Plan.

AN ANTHOLOGY - LOCKS AND DAM 26 (R), SECOND LOCK - ATTEMPTING TO DEFINE TOW TRAFFIC IMPACTS

Eugene G. Buglewicz*

Background

Locks and Dam 26 Replacement, Second Lock Project, is a unique and complex project. Its story begins in 1968 when a replacement project was recommended by the US Army Engineers District, St. Louis, Missouri, and provided for the construction of a new dam and two 1,200-ft locks located 2 miles downstream of the existing lock and dam near St. Louis. In 1969, the Board of Engineers for Rivers and Harbors (BERH) recommended immediate implementation of the recommended plan, and the Secretary of the Army approved the project under the authority of the River and Harbor Act, 1909. The Secretary of the Army advised the Congress which subsequently appropriated funds for design in fiscal year 1970. Lawsuits against initiation of construction were filed in August 1974. The Corps of Engineers was enjoined from proceeding with construction until; (1) consent of Congress was obtained; and, (2) the environmental impact statement (EIS) was revised to the satisfaction of the court.

Having met the additional EIS requirements, review by the BERH, and having transmitted the total package to Congress, the replacement project was authorized for construction, along with the following items: (1) a 1200-ft lock; (2) a requirement for a Master Plan to address the need for a second lock and proposals for managing the Upper Mississippi River; and, (3) a report to Congress.

Master Plan Recommends Second Lock

Replacement Project construction was initiated in late 1979, and items 2 and 3 accomplished by 1 January 1982. Those who were involved in the Master Plan formulation can attest to the significant amount of effort that went into the formulation of that document. In August 1985, a second lock was authorized based on the recommendation in the Master Plan. One of the recommendations of the Master Plan was that the Master Plan serve as the as National

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Environmental Policy Act (NEPA) document for the project; however, Congress did not exempt the project from NEPA. Anticipating the requirement for an EIS, the St. Louis District initiated planning for the EIS in March 1985, and issued a Notice of Intent to prepare an EIS in June 1985. The initial intent in planning for the EIS was to use the Master Plan information as the basis for the impact assessment. No need was seen at that time to collect additional information. New data which had been collected and analyzed between the Master Plan formulation period and the initiation of the EIS was reviewed. The Master Plan, however, was the most comprehensive and current analysis on the Upper Mississippi River to date.

Future navigation traffic scenarios

One of the first tasks was to describe the most probable future with respect to navigation traffic. The Master Plan had evaluated a number of different future navigation traffic levels, called scenarios. The St. Louis District evaluated the scenarios, selected one, and presented that to state and Federal agencies for their comment at a scoping meeting in August 1985. As a result of recommendations voiced at the meeting, different scenarios were selected for impact evaluation. Scenario III described navigation traffic on the Upper Mississippi River in the context of an optimized navigation system which included possible (but not necessarily justified) actions that the navigation industry or the Corps of Engineers could do to move traffic in the most efficient way. Scenario III became the "without" project condition. Scenario IIIA added a second lock to those measures and become the "with" project condition. The predicted levels of traffic for the "with" and "without" conditions are shown in Figure EIS-5 and Table EIS-17 in the Draft EIS dated September 1986.

Essentially, the traffic analysis indicated the following: in the year 1990, traffic would approximate 128,000,000 tons; and, by the year 2040, with no second lock, traffic would increase to a level of 140,000,000 tons and be constrained thereafter. With the project, traffic levels would increase to 174,000,000 tons, and at that time become constrained.

The difference between the "with" and "without" project is 34,000,000 tons. The impacts are the difference of the two. However, the situation was far more complex than the difference between these two conditions.

As discussed earlier, the Master Plan was used as the basis for impact analysis. The Master Plan and its appendices were reviewed by the District

and Division staffs. Based on that review, it was concluded there was little or no information to quantitatively evaluate navigation impacts that were so affirmatively stated in the Master Plan documentation. The St. Louis District enlisted the aid of the Waterways Experiment Station (WES) to assist in evaluating the Master Plan and supporting documentation. WES had been previously involved in review of the technical reports of the committees that had input to the Master Plan, and had a complete file of working papers that made up the Environmental Report/Appendix of the Master Plan.

Master Plan review and conclusions

Master Plan studies which were to have addressed impacts of navigation traffic on the Upper Mississippi River had to be rescoped due to a delay in receiving funds. The studies, originally scheduled for 4 years, had to be shortened to 2 years. A request for an extension of time to complete the studies was denied by Congress.

Therefore, many of the "results" of studies were a rehash of literature reviews, based upon analysis of data that existed prior to study initiation.

Analysis and definition of impact were accomplished by "concensus" by the Environmental Work Team. The work team stated that it was "confident" that the findings of this report was valid. However, systemic studies of the impact of navigation on the Upper Mississippi River System (UMRS) ecosystem have not been completed due to rescoping."

After technical review of the environmental work team reports, the environmental appendix, and other technical documentation, we began to have grave doubts concerning the technical validity of the impact sections of the Master Plan. It became all too obvious that the impacts described in the Master Plan, in fact, were: (1) conjecture; (2) based on "consensus"; (3) simply overstated; or, (4) technically flawed.

The Master Plan impacts were more a litany of all of the possible impacts that tow traffic could impose on the UMRS rather than an objective analysis of impacts and their significance to resources of concern.

In conclusion, the Environmental Work Team effort offered very little information that was usable for impact analysis. It was hoped that the US Fish and Wildlife Service (USFWS) Coordination Act Report for the Second Lock Project would be helpful in determining impacts to significant resources in an objective manner. Corps of Engineers personnel were invited to sit in on "impact panels" in which the various reaches of the river were evaluated for

navigation traffic impacts. The draft Coordination Act Report consisted of essentially the same type of verbiage contained in the Master Plan. Essentially, the analyses were qualitative and speculative.

Model Study Examinations

Resuspension of bottom materials due to the passage of tow traffic on the Upper Mississippi River was investigated during development of the Master Plan and predictions of the rate of loss of backwater habitat due to tow traffic were available. Backwater sedimentation was estimated by the St. Louis District and reported in the draft EIS (September 1986). That analysis showed that on a yearly basis, 3,537 acres of side channel and backwater habitat would convert to bottomland forest as a result of second lock traffic on both the Upper Mississippi River and the Illinois River.

A review of the simulation was conducted because rate of sedimentation in backwaters was not the purpose of the modeling work. Further, it was doubtful to many of us who have worked on the Mississippi River that such a small increment of traffic increase (34,000,000 tons) could cause such a large rate of loss on rivers as large as the Upper Mississippi and Illinois, considering all sediment sources, both natural and man-made.

Our conclusions, based on a review of Master Plan data, collection of quantitative habitat data on habitats on the Lower Mississippi River, and personal experiences were that the sedimentation impacts presented by the Federal and state agencies were in fact occurring, but were minor when considering the resource base of the Upper Mississippi River and Illinois River. These conclusions were reached using professional judgement and not "hard" data. The District subsequently updated the sedimentation simulations using more precise and updated information. The updated model indicated that, "These resuspended sediments along the towline have little or no effect on the natural life of the backwater areas and side channels."

Development of Impacts Data Base

It appeared that there was no substantial body of quantitative field data on which to base impacts due to tow traffic. Resource agencies claimed extensive environmental damage due to an additional 34,000,000 tons of traffic.

The Corps of Engineers acknowledged these effects, however, and concluded that the overall impacts were minor. The only recourse left to the Corps was to evaluate significant resources claimed to be impacted using existing impact methodologies, or, develop a data base for this purpose. The preferred method was to evaluate significant resources using current habitat-based or user-day methodologies.

Available habitat-based and user-day methods were investigated to determine if any could be used or adapted to address navigation traffic impacts. An interagency team was assembled to assist the St. Louis District in selecting an appropriate method. After significant effort the District stopped the work, concluding that there was no currently available method to determine impacts due to navigation traffic because: (1) there are no quantitative field data which demonstrate that commercial navigation traffic negatively affects significant resources; (2) quantitative relationships between tow traffic and biological impacts are not known; and (3) no measurable acreage changes in habitat types can be attributed to the incremental increase in tow traffic.

In the meantime, there is a need to publish a Supplement to the Draft EIS (SDEIS). The decision is made to defer any major mitigation discussion in the SDEIS, except to document the ongoing studies and present preliminary conclusions regarding impacts. The St. Louis District's only recourse in the face of major disagreement with the resource agencies and serious lack of substantiating data or impact assessment methodology is to prepare a document that identifies studies and research information necessary to quantify impacts due to navigation traffic and incremental increases of traffic due to the second lock. Only by establishing credible impacts and measuring their significance can mitigation be addressed.

From this point in the anthology, the St. Louis District continues with its plan to distribute the final EIS in July 1988. A Plan of Study for identifying information necessary to indicate impacts to significant resources on the Upper Mississippi River is due in January 1989.

QUANTITATIVE OBSERVATIONS AND PREDICTIONS OF THE ENVIRONMENTAL EFFECTS OF NAVIGATION TRAFFIC

Barry S. Payne*

Background

The confidence with which any predictive model can be used is dependent upon how precisely the model depicts reality. Models reduce a diverse array of information to concise, and ideally, testable hypotheses. Thus, models help direct subsequent investigations to verify, reject, or revise working hypotheses. The best models are based on many careful observations of ecological relationships that are particularly relevant if not identical to the relationships modeled. The confidence with which a model can be used depends directly on the quality and quantity of the observations upon which it is based. Whether predictions are of the environmental effects of navigation traffic or of any other ecological relationship, a good predictive model must be based on an adequate set of quantitative observations. The difficult task usually faced by individuals in environmental planning branches of Corps of Engineers Districts and field offices of the US Fish and Wildlife Service is to use and foster further development of good models. To accomplish this task, environmental managers must be able to critically evaluate the empirical basis of a model in relation to its use and subsequent development and testing.

A Simple Example

A simple empirical model of a relationship between snail thermal tolerance and habitat conditions is shown in Figure 1. Thermal tolerance (water temperature at which 50 percent of test snails enter into an irreversible coma) is shown as a function of the location of their lake or pond habitats along an east to west gradient Texas. Climatic and vegetational differences along this gradient are such that more westward habitats have generally warmer maximum summer water temperatures (McMahon and Payne 1980). In this example,

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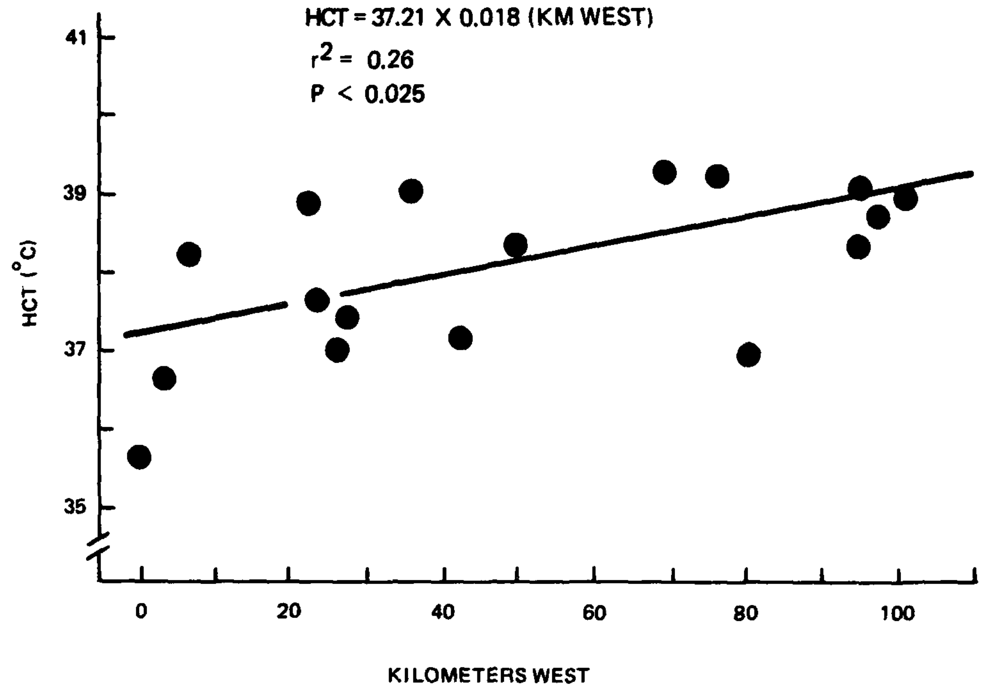

Figure 1. East to west distribution of heat coma temperatures (HCT) among 17 natural populations of the pulmonate snail, *Physa virgata*, in north Texas (after McMahon and Payne (1980))

a simple linear regression equation is the model. The regression equation is an attempt to reduce a number of observations to a simple hypothesis. Although the regression equation fit to the data in Figure 1 is "statistically significant" (slope is significantly greater than zero at probability level of 0.025), the predictive utility of the equation is poor ($r^2 = 0.26$). The r^2 value indicates the amount of variation in the y variable that is explained by its linear relationship to the x variable; in this instance, only 26 percent of the variability in heat coma temperature is due to the location of populations along the east to west cline in north Texas.

Despite the wide scatter of data in Figure 1, it is not unlikely that a consensus opinion could be developed to support the hypothesis represented by the regression equation. Furthermore, with information on the relationship of average summer water temperature to the position of habitats along the east-to-west cline portrayed in Figure 1, a more generally useful (i.e., applicable to habitats regardless of their location) model could be proposed based on information in Figure 1. The proposed new model is shown in Figure 2. Such a model might be used to predict impacts of the operation of power plants that

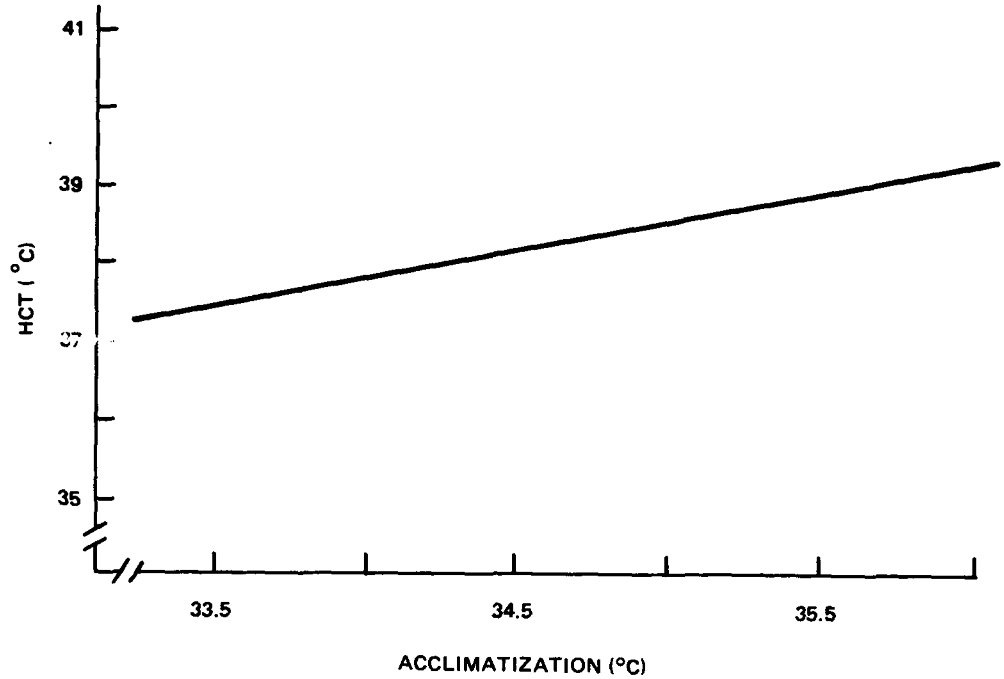

Figure 2. Hypothetical model of HCT as a function of acclimatization temperature of Physa virgata based principally on data in Figure 1. (See test for further discussion.)

return heated effluents to lakes or rivers. The type of model shown in Figure 2 is fundamentally the same as a "suitability index model" used in a habitat evaluation procedure analysis. Namely, a biological response is shown as a simple quantitative function of a measurable environmental variable. If thermal tolerance (the y axis) was normalized on a scale of 0 to 1, then a typical suitability index model would exist.

However, a model such as that portrayed in Figure 2 must be developed and used with great caution. The model is based on literature review, expert opinion, and directly relevant observations (Figure 1) -- all suggesting that there is a positive and generally linear relationship between thermal tolerance and temperature acclimatization. However, use of the model in Figure 2 would lead to specific quantitative predictions without conveying uncertainty clearly deserved (note the scattter of data in Figure 1). Also, the empirical model shown in Figure 1 cannot be legitimately used to make predictions about thermal tolerance and habitat conditions beyond the range of its observations (i.e., it is not valid to predict a y value for x values greater than 36° C). Expert opinion and literature review both suggest that the

relationship in Figure 1 would become less noisy (i.e., have a higher r^2) with more observations, principally by including a wider range of observations. The relationship would then have greater predictive value when transformed into a model such as that in Figure 2.

It is a common and often true lament of researchers that additional studies would buoy their working hypotheses. It is also true that additional studies sometimes sink hypotheses. Critical inspection of the empirical basis of predictive models is the only objective criterion for determining if and with what level of confidence a predictive model can be used. One must be extremely wary of the use of models, such as portrayed in Figure 2 or a typical suitability index model, that predict a single value of a biological response to a particular value for a measureable habitat variable. The confidence with which such models are used should be based on the clarity of the relevant data upon which they are founded.

Consequences for Navigation Effects Predictions

Too often, predictive models are developed and used with only casual or no regard for their empirical basis. Quantitative models with far less support than the example in Figure 2 have been and continue to be used to to make quantitative predictions of the environmental effects of increased navigation traffic. For example, it has been estimated that tows currently add 2 to 28 percent of the annual sediment volume entering upper Mississippi River backwaters, and that projected traffic increases will add 6 to 44 percent (Carmody, Bade, and Rasmussen 1986). However, no one has published results of an empirical investigation in which backwater sedimentation rate was studied in relation to tow passages in the upper Mississippi River. These predictions are based on theoretical models that are <u>not</u> based on actual observations of backwater sedimentation. Furthermore, despite the intense debate concerning such predictions, there appears to be little interest in performing these measurements. A history of near total lack of quantitative research to clarify any long-debated environmental impact issue (such as the system-wide effects of increased navigation traffic on backwater sedimentation) is not soley the consequence of lack of interest by academic researchers. It is likely that there are more important and tractable issues for serious quantitative environmental research and prediction.

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AN EXAMPLE OF ANALYSIS OF POPULATION CONDITION USING SIZE DEMOGRAPHY DATA: MUSSELS IN THE LOWER OHIO RIVER

Barry S. Payne*

Background

Recruitment, growth, and survival must be assessed to determine the present and project the future condition of any natural population. These properties of populations are generally assessed by monitoring changes in density and size demography of natural populations (e.g., Hunter 1961; Aldridge and McMahon 1978; Burky, Hornbach, and Way 1981). Demographically, complete censuses have rarely been made of unionid populations in mainstream river shoals (Miller and Payne 1988), despite the great attention that is focused on preservation of these animals. Quantification of recruitment, growth, and survival of naturally occurring cohorts in such populations will improve man's ability to protect the much diminished, yet still diverse, assemblage of North American unionids that is jeopardized by habitat destruction, potential commercial overexploitation, and deleterious effects of various industrial, municipal, and navigational uses of inland waterways.

The purpose of this paper is to show how basic monitoring of recruitment, growth, and survival of the dominant unionid in the lower Ohio River, *Fusconaia ebena*, can be applied to assessments of population condition in relation to commercial navigation traffic and mussel harvesting. The basic monitoring effort has been published in detail (Payne and Miller 1988` and is only summarily described herein as necessary.

Methods

Replicate quantitative samples of substrate were collected in the fall of 1983, 1985, and 1987 by divers equipped with SCUBA and sieved to obtain all mussels regardless of size. The shell length (SL) of each mussel was measured, and condition assessments were also made involving tissue and shell mass measurements. More detailed descriptions of the site, bivalve community,

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and sampling methods, and data analysis are provided elsewhere (Miller and Payne 1988; Payne and Miller 1988).

Results and Discussion

Seventy-one percent of all F. ebena collected in 1983 belonged to a single cohort of individuals with an average SL of 15.8 mm (range = 12.8 to 19.5 mm) (Figure 1). The average SL of the dominant 1981 cohort had increased to 29.5 mm (ranging from 23.0 to 38.4 mm) by fall of 1985 (Figure 1). The 1981 cohort still comprised 71 percent of total sample of F. ebena in 1985, due to low mortality of this dominant cohort combined with lack of strong recruitment since 1981. The average SL of the 1981 cohort had increased to 47.3 mm (range = 35.5 to 56.0 mm) by late September 1987 and the relative abundance of this cohort remained undiminished at 74 percent. The 1987 survey also yielded two minor cohorts of recent recruits, centered at 15.2 and 23.3 mm, representing recent but light recruitment to the population.

Sexual maturity appears to be achieved during the fifth full season of growth, and first reproduction probably occurs the next summer at an average age, SL, and tissue dry weight (TDW) of 6 years, 45 mm, and 0.9 g, respectively (Payne and Miller 1988). The maximum length of F. ebena, averaged from 1983, 1985, and 1987 SL distributions, is approximately 88 mm (Figure 1). This length corresponds to a TDM of 6.5 g (Payne and Miller 1988). Thus, individuals increase seven-fold in TDM during the reproductive lifespan.

Fusconaia ebena is the most commercially valuable freshwater mussel in the lower Ohio River. Adults are collected using crowfoot brails or by divers equipped with SCUBA, and shells are shipped to the Orient where they are processed into inserts to produce cultured pearls. Quantitative data on growth rate, size at first reproduction, reproductive lifespan, size-to-fecundity relationships, population density, and population recruitment patterns are needed to estimate maximum sustainable yields. Strong recruitment of F. ebena occurs sporadically and reproductively active females vary seven-fold in mass from their first to last year of reproduction. In general, fecundity is proportional to mass in freshwater mollusca (Calow (1983) and references within). Thus, the reproductive value of small but mature F. ebena is much less than large, mature individuals. Yet the size limit for sale of F. ebena to commercial shell buyers is 63.5 mm SL, corresponding to only 2.4 g TDM. The average

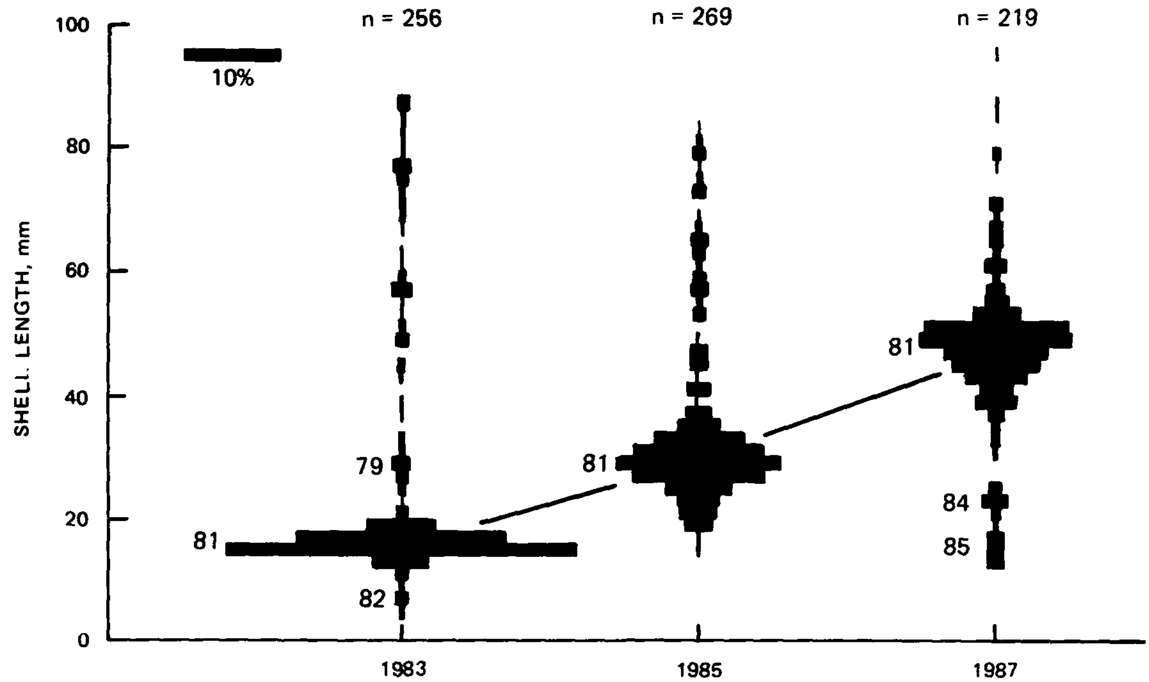

Figure 1. Shell length and frequencies for F. ebena from the lower Ohio River (figure from Payne and Miller 1988)

maximum adult size is 6.5 g. Thus, only the reproductively least valuable portion of the population is protected by this size limit. In addition, smaller mussels are inadvertantly collected and dumped back into the river. Many of these individuals are unable to reburrow and are likely to die (Imlay 1972; Miller et al. 1987). Commercial overexploitation of distinct beds, especially when harvests are made by divers, could quickly destroy large populations such as F. ebena in the lower Ohio River.

In addition to concern regarding overharvesting, much concern exists regarding the effects of gradual increases in commercial navigation traffic. It is thought that increases may deleteriously affect the growth and survival of riverine mussels via generally increased frequencies of turbulence and resuspension of bottom sediments (e.g., Rasmussen 1979). The population of F. ebena has existed for decades (Williams 1969) in a shoal bordering the commercial navigation lane in the lower Ohio River. Recruitment success determines the abundance of unionids in this shoal. Studies are continuing in an attempt to determine what environmental factors were responsible for the exceptionally strong recruitment noted in 1981. Nonetheless, it is virtually impossible that navigation traffic determines recruitment patterns in this

mussel bed. Traffic rates have not substantially changed from 1981 through 1987, but mussel recruitment has varied annually by several orders of magnitude (Figure 1). In addition, growth rate and survival of the dominant 1981 cohort are high despite the proximity of this shoal to a major commercial navigation lane. Effects of navigation traffic are of clear concern in specific areas, such as new or expanded sites of barge fleets, where turbulence levels and frequencies are higher than associated with routine traffic (Aldridge, Payne, and Miller 1987; Payne and Miller 1987; Payne, Miller, and Aldridge 1987). Navigation-related loss of mussels is more likely to result from site-specific activities such as expansion of ports and barge fleeting areas or dredging of stable shoals than gradual increases in traffic rates along historically used navigation lanes.

Conclusions

The continued existence of most unionids in large inland rivers depends on protection of remaining beds and stable shoals from destruction by siltation, dredging, or sustained degradation of water quality (Stansbery 1970) as well as prevention of overharvesting of commercially exploited mussel beds. Assessments of the health of remaining mussel beds must be based on long-term quantitative studies of recruitment, growth, and survival of cohorts of dominant populations. Quantitative samples of substrate should be taken so that density and size demography of populations can be accurately assessed (Miller and Payne 1988). Detailed ecological studies of recruitment at major mussel beds in large inland rivers are likely to prove crucial to the preservation of remaining unionid populations.

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TECHNIQUES UNDER DEVELOPMENT TO PREDICT NAVIGATION TRAFFIC IMPACTS

Terry Siemsen*

Abstract

The Navigation Planning Support Center, US Army Engineer District, Louisville is developing techniques to predict the future effects of commercial navigation traffic. These techniques are designed to assess the relative differences in impacts among alternative traffic scenarios that occur with different structural courses of actions. The techniques under development are planned to be used on actions in planning stages, primarily during feasibility stage analysis. These studies will coincide with a need to address impacts in project Environmental Impact Statements and under the Fish and Wildlife Coordination Act.

A "cause and effect" relationship is used to relate the variable forces caused by moving vessels on organisms occupying a river reach. Equations to describe forces generated by tows in varying channel geometry are being developed to predict these forces in various zones of a channel cross section. Biological models are used to assess potential impacts and are kept to species or a specific species life stage level. The purpose of using specific life stage levels is to maintain an ability to focus expected impacts to allow modifications to proposed plans or, if warranted, determine mitigation needs. A software system is being completed that will merge future traffic scenarios, expected physical forces, species to characterize the river reach, and data to describe the reach of interest. This software system will allow an early stage assessment of the potential for impacts, the level of significance of expected impacts, and incremental analysis of mitigation concepts.

The projections of future commercial traffic on the Ohio River system indicates increases in tonnage with projected average tons per tow and/or increased tow passage through the foreseeable future. These increases may also be accompanied by increases in the percentage of larger horsepower towboats as tow size increases. The net effect of vessel changes, vessel numbers, and fleet changes may cause modifications in the available habitat for aquatic

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species. Effects will likely be most significant proximal to the project(s) under review with decreased effects in adjacent pools as the traffic pattern modifications are diminished.

For a typical project, modifications of a lock and dam to increase lockage capacity may change the projected growth patterns as compared to no change in the navigation structure. The future characteristics of the fleet, tonnage, and number of tows are dependent on the extent that restrictions are removed from the waterway and the size of lock chambers (lock capacity) considered. Ultimate effects, on an incremental basis, are then based on these unique fleet considerations for each potential project alternative.

Analysis Method Concept

The effects of modification of a lock and dam to increase the physical lock capacity will be long-term and likely quite subtle since the expected growth in any 1 year is small. Over a 50-year period (typical for planning level studies), the change in commercial traffic will likely be significant and the potential for change to the aquatic community is possibly significant for certain species life stages. Because an assessment of this potential for change is needed in the project planning phase, an examination of the potential effects on the available habitats in the river reach of interest is needed.

An examination of the presently available habitats is needed since no significant data base exists that allows an extrapolation of the past modifications of navigation traffic and organism response. Relatively few studies have been conducted regarding the potential effects of tow traffic on organisms. Most of these studies have focused strictly on organisms with little or no correlation to the forces created by moving vessels, presumably the cause of the presumed impacts under study. The results of these few studies of organisms do not allow extrapolation of the study results to other organisms, to the same organisms exposed to a different set of tow traffic characteristics, or to a population of the same organisms at a different location exposed to any level of tow traffic.

An examination of the habitats along a length of a river reach is further needed. Extensive resource inventories of the aquatic communities in large rivers are not generally available for the Ohio River and tributaries. In

addition, key indicator species that may be considered important as a measure of tow traffic effects may occupy different portions of the available river area, even different life stages of a single key species may occupy different portions of the river at each stage of species growth. An examination of the available habitats for a river reach will allow a screening of areas that will result in a resource inventory for each indicator species. Areas not significant for a species can be eliminated from further consideration, and key areas for a species can be highlighted.

Effects that may be expected to occur can be identified at site-specific (reach-specific) locations. These locations may be as small as a few hundred feet of river length and a specific portion of the channel to longer reaches of several miles or more and for an entire channel cross section. Considerations of project modifications can be reviewed to identify means for minimizing or eliminating potential effects. Mitigation measures, if needed, can also be identified and reviewed to determine effectiveness for offsetting or eliminating identified impacts and, where applicable, costs assigned.

Methodology Baseline Data Needs

A river length is divided into reaches of similar habitat characteristics. Preliminary divisions are made prior to field inspection and field confirmed or modified as necessary based on observed conditions. Reaches of commonality are based primarily on cross-sectional profile, thalweg location, substrate characteristics, flow velocity distribution, and available cover.

Data that are collected include a detailed mapping of each cross section with a characterization of water depths, bottom topographic features, and the substrate and flow patterns for the section across the river. A recording depthfinder is used to obtain a depth profile and general indicator of probable changes in both substrate characteristics and flow patterns. Sites to obtain samples of bottom substrate material and flow velocity measurements are determined based on observed changes in the profile from physical features or the strength of the returned signal of the recording depthfinder echogram. Substrate characteristics and particle size are determined manually based on the greatest portion of the sample. Samples that contain significant portions of varied-size particles are so noted with approximate percentages assessed for each particle size group. Flow velocity measurements are made at 20, 60,

and 80 percent of the water depth at a particular site as well as at about 12 in. above the river bottom. Available cover features, shoreline objects, and underwater structure are recorded. In some instances, as few as four sites are needed to characterize a cross section (ultimately, a reach) while other cross sections (reaches) may require as many as 10 to 12 sites to adequately describe the available habitat.

Equipment used for the data collection effort includes a Lowrance X-16 Recording Depthfinder, a Petite Ponar Substrate Sampler, a Marsh-McBirney Electromagnetic Water Velocity Meter (Model 201), and a Leitz Precision Rangefinder.

Physical Forces Created By Towboats

The hydrodynamic forces created by moving vessels in a waterway have the potential to adversely affect organisms if a combination of intensity and frequency is sufficient. The primary forces generated by moving vessels include propeller jet and intake velocities, bow wave, return flow both under and alongside the vessel, wake flows, and diverging and transverse waves. Secondary effects include substrate displacement and scour, periodic elevated suspended solids levels, and increased episodes of sediment deposition.

Propeller jet velocities can be predicted with relative certainty at distances extremely close to the propeller. Velocity patterns are altered drastically with distance because of the destructive forces of flow turbulence and shear. Organisms in the jet are subject to extremely rapid deceleration and shear, forces that can injure large organisms and rupture small organisms. Mortality for organisms, particularly small and/or early life stages, in this zone of the water column is high. Jet velocity has the potential to significantly disturb bottom material in shallow portions of a river if a vessel has minimum blockage coefficient and little speed relative to the water column. As vessel speed, blockage coefficient, and water depth, individually or combined, increase, the result is lesser amounts of jet velocity reaching the river bottom and a reduced ability to disturb substrate. With these factors in the proper combination, the potential exists for the propeller jet velocity to be dissipated or deflected toward the surface and not reach the river bottom.

Propeller inflow velocities can be estimated with relative certainty at

the inflow side of a propeller. As distance ahead of the propellers increases, the inflow patterns under a vessel are combined with return flows. The contribution of inflow in this overall flow of water becomes difficult to isolate and quantify. The inflow pattern also varies with barge configuration and barge draft. Water flowing into the propeller zone carries with it free-floating organisms that are subject to mechanical injury or destruction and are injected into the turbulent shear zone in the propeller jet.

A moving vessel also creates a bow wave that is visible as an increase in surface water elevation and is also apparent underwater with changes in water flow patterns. This bow wave will vary with tow speed, barge configuration, and barge draft. The change in surface water elevation seldom exceeds 1 ft for most tow configurations and is relatively innocuous to organisms. The underwater component is significant in that recorded changes in flow patterns occur as much as 500 ft ahead of a moving tow. Bow waves may cause organisms to be deflected from the path of the tow, decreasing their chance of injury or loss by impingement and/or entrainment through the propellers. Since adult fish have the capability to sense small changes in water velocity and take avoidance action if warranted, the underwater component of a bow wave likely acts as a 'signal' to adult fish which may cause some individuals to move to avoid an oncoming tow.

Return flow has several components that may be referred to by terms such as displacement flow and drawdown but are grouped in this discussion. The frontal area of a moving vessel causes the displacement of a significant volume of water; the magnitude of this displacement depends on the width, draft, and speed of the vessel relative to the water column. The displaced water must flow either under the vessel or around the sides of the vessel. The amount of a river channel that is affected by these flows is dependent on the vessel frontal area, vessel speed relative to the water column, the cross-sectional area of the channel, and the sailing location of the vessel in the channel section.

Return flows under a moving vessel typically peak at the point of maximum draft and, depending on vessel speed, may be the greatest flow component exercised on the substrate by the passage of a tow. The magnitude of return flows under a vessel will vary depending on whether the vessel is upbound or downbound and the ambient river flow velocity. These flows are counter to the direction of vessel movement. Return flows of as high as approximately

3 fps on the channel bottom have been observed in rivers with little ambient flow.

Return flows around the sides of a moving vessel peak near the side of the vessel and decline with distance in a shoreward direction. The extent and magnitude of the decline varies with the speed and the frontal area of the vessel, the channel width, and the location of the vessel in the cross section. All other factors being equal, the magnitude of return flow also varies between upbound and downbound vessels. Return flow velocity also varies between the starboard and port sides of the vessel since no natural river has a continuous, prismatic channel. Return flow alongside a vessel moves counter to the direction of the moving vessel.

Drawdown is a lowering of the water surface induced by the bow wave and developed return flow of a moving vessel. Water moves away from nearbank areas, with a directional component that changes from generally perpendicular to a bank to approximately 45 deg from a bank in a downstream direction. Drawdown magnitude varies with return flow and bow wave components and is heavily influenced by the location of a vessel in a channel cross section. Drawdown has the potential to dewater shallow nearbank areas for short time intervals, generally less than 60 sec. Because of the velocity component associated with drawdown, the potential exists for displacement of sediments and organisms that have little or no mobility of their own into deeper offshore waters.

Wake flow is the flow that "fills in" behind a moving vessel, particularly one that has a large frontal area. Wake flows are return flows from alongside the vessel that are turned 90 deg from alongside a tow into the path immediately behind a tow and then turned 90 deg again to be flows in the same direction of the vessel movement. The return flow from under a vessel does a similar 180-deg reversal to become a flow following the vessel. It is the wake flow component that originates as a return flow alongside a vessel that keeps a sediment plume behind a vessel from spreading to an infinite width.

A moving fleet creates both diverging and transverse waves. The diverging wave train originates from the bow of the lead barge, the stern of the last barge, and, occasionally, the stern of the towboat. These waves typically move at an angle of about 20 to 30 deg of the axis of the path of the vessel. Transverse waves are generated alongside the fleet and travel in the same direction that the vessel moves. The magnitude of waves generated by

moving tow fleets is primarily influenced by the speed of the vessel. Diverging waves as high as 3 to 4 ft, crest to trough, can be generated but waves of 1 ft or less, crest to trough, are typical. Transverse waves are generally smaller than diverging waves and are not of themselves generally significant. The intersection of the diverging and transverse waves can, however, be additive and create a somewhat greater wave, crest to trough, at the location of convergence. This additive effect does not continue, rather the diverging wave returns to approximately its original magnitude after the intersection.

The motion in generated waves is orbital. In deep water where the waves are generated, the motion is spherical. As the waves move into shallower water, the motion becomes elliptical. As the wave moves into shallower water, the energy of the wave also begins to dissipate. The energy of the wave is ultimately dissipated as the wave encounters the nearbank zone. This energy has the potential to displace and suspend sediments in the water column. The wave energy has the potential to dislodge or overcome organisms with little or no ability to move on their own. Waves also have the potential to strand organisms as the waves break and run up a bank and also to draw organisms out into deeper offshore water.

The physical actions of these forces can be manifested on organisms, particularly those with little or no ability of their own to escape. Organisms that occupy the bottom sediments and are sedentary in nature are often food sources for other organisms. Disturbance or scour of the first inch or more of river substrate can dislodge these organisms, expel them into the water column, and possibly depopulate the substrate. Natural colonization begins a recovery from this action but a depression in the availability of the food resource occurs. Some organisms use the substrate for reproduction. In this case, dislodgment could result in direct loss of organisms, depending on the magnitude of the disturbance. Disturbance of the substrate will result in the material ultimately being redeposited. Depending on the deposition pattern and extent of material, benthic organisms can be smothered, but again recolonization begins to repopulate the area. Organisms that use the area for reproduction may again have a direct loss.

Biological Models as Indicators of Commercial Traffic Effects

The generated forces of moving vessels have the potential to cause impacts on aquatic species. The forces generated by moving vessels may have little effect on some organisms but, in some cases, the effects on other organisms may well be significant. Further, these forces may not affect the same species life stages all in the same manner.

Species can be selected that serve as indicators of effects of the aquatic community. Species of fishes, as organisms that all occupy some portion of the water column, can be selected to serve as indicators not only of impacts to them as consumers high on the food chain but also as a gage of the health of other aquatic life such as invertebrates since they can be assessed as a food source. A guilding type of procedure can be conducted to determine the species that are present that occupy the available habitats for all life stages.

To assess the effects of traffic movement on aquatic species, the Concepts of Habitat Evaluation Procedures (HEP) and Instream Flow Incremental Methodology (IFIM) are employed. The basis of these methods are the concept that areas and volumes of aquatic habitat can be characterized for the potential for a species life stage, and that man's actions can be applied to determine whether or not a response is expected, along with the magnitude of the response. HEP and IFIM cannot be used in their present form since they have not been developed to evaluate pulsation type impacts where an effect occurs for a period of time and then conditions return to ambient with another pulsation to follow.

Habitats are evaluated based on ability to allow an organism to find food, find cover, and be able to reproduce. These habitats are then ranked based on these factors to determine, on a numerical basis, how good an area is with a rating of 1.0 being optimum.

Species models have been developed to account for pulsation impacts for Sauger, Spotted Bass, Channel Catfish, Freshwater Drum, Black Crappie, Emerald Shiner, and Paddlefish to provide a representative group to evaluate the food, cover, and reproductive requirements in the habitats that may occur in a study area. Species from this list that are applicable are used and are supplemented with other species for which models have not yet been completed. Only certain life stages are used in species models since connections of "cause and

effect" between tow forces and biological effects have not been developed at this time for all life stages.

Each of the reaches mapped will be evaluated for the habitat potential for each of the chosen indicator species life stage. Those reaches with little or no potential for a given species life stage can be eliminated from further consideration since there would be no resource base to impact.

The biological models include consideration of impingement and entrainment through the propeller intake and jet flows. The models account for the species which seem to prefer to feed on bottom organisms, particularly noting those which prefer the main channel areas and those which prefer nearbank regions. The models account for those species which use portions of the water column where food sources may be dislodged or eggs/larvae may be displaced. The displacement of eggs and/or early life stages into other portions of the water column may result in increased predation and would lower the value of a reach for continued recruitment of a species. The models account for the potential that jet velocities may make areas with otherwise suitable structure unusable because of periodic blasts of high water flow. The model also accounts for the potential for elevated suspended solids levels to depress the value of a reach and for the ultimate deposition of suspended material to exceed a species capability to respond.

Anticipated Output From Analysis Model

The output will provide a numeric evaluation of the gains/losses in habitat for each species life stage. Output will be similar to traditional HEP and IFIM studies in that the numbers are in "habitat units" which are a product of available habitat area and quality. This output will result in a comparison of the "without" project fleet conditions and for each of the alternative fleets that would result from considered alternatives for each of the future years in the economic analysis.

The numeric result will be available for each reach within the study area, and any reach that gains/loses more than 5 percent of the habitat value as compared to the "without" project condition will be flagged for specific review. First review of any reach with losses would be means to reduce or minimize project effects through good design and environmental practices. Review of a particular reach may identify effects to a species life stage that

has limited habitat availability and result in recommendations that traffic patterns should be modified. These modifications may take the form of traffic changes in a certain future year or at a certain future tonnage/tow frequency condition to direct tows into a pattern that lessens project effects. Review of effects may also show that the flagged reach indicates losses to a species that is considered relatively resilient and the effects are not significant and no actions are warranted. The same steps may be appropriate for mitigation measure review.

It is not inconceivable that in any section an attempt to balance or minimize losses will affect species differently, causing reduction of losses in some species with coincidentally increased losses in other species. In these cases, a review again will be made of the relative availability of suitable quality habitat for the affected species and a decision made to which species has the greatest needs for minimizing impacts.

Mitigation measures may be warranted in some cases. Impacts that may be anticipated can be specifically identified. Mitigation measures can be proposed and tested to determine if the proposed measures are effective. A judgement can be made if the amount of mitigation is too little, too much, or approximately correct. In this manner, mitigation can be an incremental analysis. The steps could be as simple as placing material presently dredged and disposed in a thalweg area into an area well out of the navigation channel and creating an island and a back channel area with minimal increases in project costs. Because the traffic scenarios are analyzed for the target years in the economic analysis, timing of mitigation can be analyzed. Mitigation strategies could be developed to require mitigation measures to be implemented only at some future year, tied to traffic level/fleet characteristics at which implementation would only occur, or reducing the amount of overall mitigation and implementing it sooner and "banking" habitat units against future projected losses.

SUMMARY OF THE WORKSHOP

Andrew C. Miller*

Background

On 5-6 April, 1988, a workshop on commercial navigation traffic effects was held at the US Army Engineer Waterways Experiment Station (WES). The purpose was to review and discuss techniques to measure and predict the environmental effects of commercial traffic. The workshop was attended by planners and biologists from Corps of Engineer District and Division offices, the Board of Engineers for Rivers and Harbors, and the Office of the Chief of Engineers.

Synopsis of Major Presentations

Mr. Eugene Buglewicz, Lower Mississippi Valley Division (LMVD), reviewed the Lock and Dam 26 (Replacement) Project, and indicated that previous studies on the Upper Mississippi River and findings of "impact panels" provided little useful information. ("An Anthology - Locks and Dam 26 (R), 2nd Lock - Attempting to Define Tow Traffic Impacts," Eugene Buglewicz.) This will be remedied by having the US Army Engineer District, St. Louis (LMS) prepare a plan of study to evaluate the effects of traffic on significant resources. Mr. David Gates, LMS, discussed a procedure used to identify areas suitable for barge fleeting along the Mississippi River. The technique, actually a modified habitat evaluation procedure, consisted of having an interagency team evaluate a river reach and rate sites based on their susceptibility to development. ("A Conflict Resolution Method for Shoreline Management Decisions," David Gates and Kenneth Porter.) Mr. Steve Cobb, LMVD, described a geographic information system that could be used to identify significant resources for a navigation impacts study.

Personnel from the US Army Engineer Districts, Nashville, ("Nashville District Overview of Navigation Related Studies," Richard Tippit) Mobile, Rock Island, and Pittsburgh offices described navigation projects that require

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environmental studies. Major concerns expressed during these presentations included: (1) There may be difficulties in extrapolating results of navigation effects studies conducted in alluvial rivers to rivers with hard substrate; (2) There will be difficulties in predicting environmental effects when water quality in a watershed is improving; and, (3) It is difficult to predict effects of future traffic at sites already affected by navigation. Mr. Terry Siemsen, US Army Engineer District, Louisville, described his work on modifying habitat-based methods to predict impacts of incremental increases in traffic ("Techniques Under Development to Predict Navigation Traffic Impacts," Terry Siemsen). Mr. John Furry discussed physical studies that are being used to evaluate navigation traffic effects at lock and dam rehabilitation projects in the Huntington District.

Goals of the Workshop

This workshop was held to discuss appropriate techniques to measure and predict the environmental effects of commercial navigation traffic. Currently the CE is faced with a series of construction and rehabilitation projects on large waterways. Personnel from resource agencies and conservation groups have expressed concern that development of these projects could detrimentally affect significant resources.

During this meeting every effort was made to distinguish between measurement and prediction of effects and between site-specific (such as barge fleeting) and system-wide effects (results of extensive use of an entire waterway). Prediction of effects should not be based on conjecture, but on extrapolation of known cause and effect relationships. Studies can be designed to investigate the effects of existing traffic, but extrapolation is necessary to predict effects of increased traffic.

If Corps of Engineers personnel can agree on the need for quantitative data to make predictions, then well-designed studies of traffic effects can be implemented. This will enable Corps personnel to deal effectively with state and other Federal agencies and ultimately to protect significant resources. It is apparent that there have been few well-designed studies that deal with navigation traffic effects. ("The Value of Scientific Literature in the Study of Navigation Traffic Effects," and "Environmental Effects of Commercial Navigation Traffic -- Working Session I," Andrew Miller.) Studies of physical

effects should be designed to collect quantitative data on important biotic parameters.

Major Findings of the Workshop

The following is a synopsis of major findings of the workshop, based on the presentations, comments, and discussions:

(1) There is considerable anecdotal and unsubstantiated information on navigation traffic effects. This information has no value for predicting the environmental effects of traffic.

(2) Although commercial traffic has existed in navigable waterways for years, there is no evidence that this has caused negative systemic effects.

(3) There appears to be considerable difference of opinion within the Corps of Engineers on techniques to measure commercial navigation traffic effects. Personnel in the Louisville District are basing predictions on modified habitat evaluation procedures. The Huntington District developed an energy flow model to measure effects of tow passage on photosynthesis. There have been few studies designed to measure effects of commercial traffic on growth, density, or recruitment of significant aquatic organisms.

(4) Commercial traffic can have negative effects at specific sites. Passage of vessels can cause elevated suspended solids and accelerate water exchange between the river channel and backwaters. Personnel from the Nashville and Mobile Districts have reported that vessels moving through narrow waterways can hit or otherwise physically disturb river banks.

(5) During the workshop an approach to studying commercial navigation traffic effects was discussed. The following is a synopsis of that discussion:

A river should be separated into representative reaches based upon biological and physical conditions. A set of representative study areas should be identified. At each study area, experimental (i.e., affected by physical effects of traffic) and reference (i.e., relatively unaffected by traffic) sites should be identified. Sites should differ only on the basis of physical effects of traffic and should be similar with respect to water depth and substrate. A study with adequate replication must be designed so that data can be subjected to statistical evaluation.

Following identification of experimental and reference sites, biological and physical data should be collected. Biotic parameters should reflect basic conditions of habitat and be sensitive to stress. These should include: characteristics of individual species (physical condition indices), characteristics of dominant populations (evidence of recent recruitment and density), or community characteristics (species richness and diversity). These are best measured on nonmotile benthic invertebrates (including mussels), although some parameters could be applicable to fishes and other motile organisms. Differences in these biotic parameters at control and experimental sites can then be tested using standard statistical methods. Physical effects of traffic (i.e. changes in magnitude and direction of currents following passage of commercial vessels) should be monitored throughout the study ("Effects of Commercial Traffic on Mussel Recruitment in the East Channel of the Mississippi River near Prairie du Chien, Wisconsin," Andrew Miller, and "An Example of Analysis of Population Condition Using Size Demography Data: Mussels in the Lower Ohio River," Barry Payne).

(6) Quantitative data from site-specific studies should be the basis for predicting the effects of incremental increases in commercial navigation traffic. ("Quantitative Observations and Predictions of the Environmental Effects of Navigation Traffic," Barry Payne.)

(7) Workshop participants agreed that an interagency meeting, to include representatives from the US Fish and Wildlife Service, state agencies, conservation groups, and the commercial towing industry, should be held. Topics for discussion and presentation should include results of quantitative studies that demonstrate beneficial or detrimental effects of traffic. Participants felt that those who must deal with these issues should agree on techniques for studying and predicting navigation traffic effects.